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Contents for May 15, 1916

Flotation

The symposium on page 569 of this issue on the effect of flotation on cyanidation, the report on page 572 of the joint Mining Engineers and Electrochemical Society meeting in New York on the "how" and "why" of flotation, and the questionnaire on page 562 on theoretical and practical phases of flotation illustrate the rapid progress, which flotation is now making. To formulate a problem correctly is half the solution.

Academic Millinery

In a late number of *The Scientific Monthly* Messrs. C. G. and C. B. MacArthur of Urbana, Ill., have a great deal to say about "The Menace of Academic Distinctions." It worries them. They have seen heads under mortar boards congregating on the campus and appearing to think themselves better and wiser and more to be respected than the other fellows. The June processions of The Intellectuals in sombre caps and gowns and flamboyant hoods seem foolish and undesirable to them. The lowering of scholarship from its great task of promoting human advancement in knowledge and understanding down to so vain a show is, in the minds of these authors, not only undemocratic but poisonous in its effects. No less of an authority than William James is quoted to show the evils of "The Ph.D. Octopus." Another writer is called upon to remind us that "a dozen mortar boards on the campus are more of a menace to democracy than a million dollar endowment from a trust magnate," and the Phi Beta Kappa and Sigma Psi societies are indicated as distinctions without genuine merit, displaying no more real worth than the flaming necktie and the flowery waistcoat of the newly rich.

The protestants against the shortcomings of the universities and the emptiness of their degrees are having their day in court. We hear of them time and again. The learned counsel for the prosecution are enjoying all the usual privileges of "examination with a view to prove defective character." Now, all is fair in love and war and in a court room with an easy judge; but where we think the prosecution errs is in bringing in poor old democracy every time. Democracy is a shibboleth, it is a gospel, and we are in favor of it without knowing exactly what it is. The late John Hay told what he wished it were and we feel that way too, but all the time we are shouting in favor of democracy we are also wishing with all our hearts for system and order and for more character, more unselfishness and more intelligence among those who constitute the people under it. Slowly but surely it is being borne in upon us that democracy fails when public opinion and public conscience deteriorate, and that when democracy fails anarchy rises in its stead. Democracy is subject to a reversible reaction

and goes over into anarchy as public enlightenment and public conscience decrease, returning again to good government, stability and general order as these increase. This is a law, and there is no getting around it. The only way to avoid the rule is to give up democracy and to employ a benevolent tyrant.

Now, since democracy must have for its mere existence the advantage of enlightenment, there is as much hazard in the destructive criticism of universities on the ground that they are undemocratic and perversive of the general welfare as there is in all the processions of the intellectuals and the unhappy picture of their total wives engaged in a snubbing contest. Destructive criticism "is in the air; it is in every stratum of society," as the metaphorist said. For instance, the beneficent anarchy desired by the I. W. W. is all right to talk about, but we know very well that the end of such propaganda is anarchy and not civilization or order. We know very well that those who follow the agitators have, many of them, serious grievances and that they do not get a chance to participate in the pleasant and agreeable things of life. They say that they are entitled to live under better circumstances, and that is right too. But we know also that they and all the rest of us have not, collectively, intelligence and character enough to establish a better order of things and that, much as we may sympathize with them, their unconscious goal is anarchy, disorder, strife and poverty.

The weakness of democracy is anarchy, and it is time that detractors of university methods and work be held to strict account and required to give for every destructive proposal, a corresponding constructive one.

Degrees are given for what is considered to be the attainment of proficiency. The occasional exchange of honorary degrees for endowments is not of sufficient frequency to count. Scholarship has always suffered from the cackle of mouths with small men about them. Let us endure it as our fathers before us have done. But the method of determining proficiency is very defective, and it has always been so because it does not distinguish the men of constructive power from the often foolish memorizers. Instead of making an attack upon the only rewards that universities have to bestow —and our passion for reward is too great to give them up—it would be far better if the detractors were to set themselves to work to devise a better method of selecting candidates, or to provide a qualification of degrees, as of, respectively, constructive and mnemonic honors. Scorn of university degrees will not lessen them; it will only cheapen them until they are so largely bestowed upon the unworthy that men of attainment will select other methods of separating themselves from the noisy crowd which sounds and smells more like anarchy than democracy. If we destroy the value of degrees it may drive the memorizers out of the new orders of the *Cognoscenti*, but it will not drive men of attainment into the crowd. The reason for this is that men of attainment do not like to talk in the language of scare-heads. The crowd to-day wants little else. Why not strive to pull the crowd up rather than to pull the teachers down?

The fact is that most men who have studied in Science or The Humanities and have not degrees, would like very much to have them. The Messrs. MacArthur say that "business men manage without titles," but that is because they lack them. They chortle with glee when they get them. The oft published Review of the Stock Market by Henry Clews, LL.D., is too frequently received by those recorded in the advertising list as "Investors" to have passed without notice. Sir Robert Burnett's London Dry Gin is emblazoned on the placards of too many street cars to have escaped observation. Sir Robert may have been gathered unto his fathers long ago, but had he received an honorary doctorate we are disposed to believe that that, too, would have decorated his many bottles of gin.

Engineers who desire to get to work without delay may not remain at the universities long enough to take a doctor's degree, but it does not seem either to injure or to shame those that do receive it. The occasional doctors that one meets with among civil, mechanical or electrical engineers do not seem to have lost merit or gained unwholesome vanity because of their titles. As for the members of the Chemists' Club, they seem to be mostly doctors, and we have yet to learn that they have lost their precious gift of democracy.

The Immortals do not need degrees. We do not think of the late Dr. Napoleon Bonaparte in connection with his university distinction, nor do we refer to them in speaking of Charles Darwin. On the other hand, we do say Professor Huxley, Professor Tyndall and Professor Haeckel without belittling them. The title indicates that they have figured as teachers.

We want titles, most of us; and we like them. We are no judges of our own worthiness to receive them because Nature has implanted in every one of us the belief that he is, in one way or another, exceptional. And because of our exceptional qualities, we like to be distinguished. We like to be known as leaders, whether as Bim the Button Man, or the Great Commoner, or the Master of Baliol. We differ in quality but not in desire.

We have in mind a chemist who took his bachelor's degree and then went to work. He worked hard and well and he was a man of remarkable natural endowments. He kept the general principles of chemistry alive in his mind and his professional attainments were far and away beyond those of a majority of men who hold doctors' degrees. He did not like snobs. Certain doctors of philosophy, who knew far less than he, put on airs and frills, and they annoyed him. So he undertook to prove that a good chemist could be as unlike them as possible. His language became vulgar, corrupt and obscene, he offended men of more gracious habit of life—and he went to pieces. These are the two extremes of evil that we face when we quarrel about university degrees: snobbery on the one hand and cultural degeneration on the other. If we only had more sense we might strike a happy medium, and the reason why we do not strike a happy medium is because we have not more sense.

Science above all other studies needs to be set forth with all the art available. A little academic millinery will do it no harm. A doctor's degree indicates a cer-

tain measure of scholarly attainment. This we need. Instead of decrying scholastic degrees we should urge as many students of science as can spare the time, to avail themselves of these great privileges of the universities.

The Domestic Demand for Steel

Despite the fact that the steel mills that produce the great bulk of the steel in the United States are highly specialized they are able to meet a consumptive demand that is distributed in quite abnormal manner among the different steel mill products. This ability to meet a demand of quite unusual analysis is due in part to the fact that steel-finishing capacity is in excess of steel-making capacity, but is due largely to the efficiency by which changed conditions have been met. The steel demand of 1906, for instance, analyzed 22.8 per cent rails, while the demand of to-day analyzes about 8 per cent rails, taking the year as a whole, and much less than 8 per cent during the winter months. The demand for large steel rounds is exceptionally heavy, due to the war, and the condition has been met by equipping many rail mills to roll these large rounds.

The export demand for steel is much more exceptional in its character than in its volume. While the fact is not realized in all quarters, the export demand for steel is not much greater than before the war, by comparison either with the total exports of merchandise or with the production of steel. Thus in 1912 the value of all iron and steel exports, covering the regular tonnage products as well as machinery, hardware, cutlery, etc., amounted to $289,128,420, and this constituted 12.2 per cent of the total exports of merchandise. In 1913 the iron and steel exports of $293,934,160 constituted 12 per cent of the total exports. In the eight months ended last February the value of iron and steel exports was $355,120,855, and this was 14 per cent of the total exports in that period, an increase of only 15 per cent in the proportion. Comparison of iron and steel exports with the total production can be made only by comparing tonnage exported with tonnage produced. In 1912 the weight of all iron and steel exported that was returned by weight was 2,948,466 gross tons, and this tonnage was equal to 9.4 per cent of the weight of steel ingots and castings produced. As the production of steel ingots and castings may be estimated at a rate of fully 42,000,000 tons, the same proportion would suggest exports of iron and steel at the rate of 330,000 tons a month. The exports in the eight months ended February averaged 370,000 tons a month, or 12 per cent more than the prescribed rate, and as exports in the two closing months of the eight-month periods were less than in the first two months it may be assumed that the rate of export has not increased since February.

The analysis of the exports, however, has greatly changed on account of the war. There are exceptionally heavy exports of billets, large steel rounds and wire products, while the exports of tubular goods, structural steel and some minor products are in exceptionally light proportions. Much attention has been directed to the extremely heavy exports of metal-working machinery for more than a twelve-month, but the exports of certain other classes of machinery, agricultural implements in particular, have been exceptionally light.

The exports of steel in rolled form, as well as the steel consumed in the manufacture of machinery, etc., that is exported, comprise but a slightly larger proportion of the total production of steel in the United States than formerly. As production is far in excess of any rate obtaining in the past, the total tonnage demand of strictly domestic character is far in excess of previous records, and yet the demand for certain classes of finished steel is abnormally light both in proportion to the total production, and absolutely, as to the tonnage involved. Rails, galvanized sheets and structural steel for ordinary building consumption are examples. By some fortunate coincidences demand in certain other directions has fit with these decreases. The demand for large steel rounds, as already mentioned, fits nicely with the small demand for rails. An exceptionally heavy demand for black sheets fits with the decreased demand for galvanized, and an unusual amount of railway structural work fits well with the relatively light demand for structural steel for other purposes.

Market prices for various steel commodities, however, show that the adjustments to a peculiar analysis of demand are not complete, or are brought about only by the payment of what may be denominated a premium. For instance, a price of approximately three cents a pound obtains for far-forward delivery of plates, blue-annealed sheets, 10 gage, and black sheets, 28 gage, when, of course, blue-annealed sheets should command several dollars a ton, and 28-gage black sheets about $15 a ton more than plates. The vagary is positively amusing, however, when prices for prompt shipment are compared, since for prompt shipment from mill 4c. has lately been paid for plates, 3.50c. for blue-annealed sheets, and 2.75c. to 2.90c. for black sheets. A tremendous premium is necessary to secure plates for prompt shipment, while shop-worn sheets have been sold at a cut price for prompt shipment.

In unfinished steel positively shocking prices obtain for steel of special quality. While ordinary soft steel billets are quotable at about $45, ordinary forging quality commands at least $20 a ton more, while steel made to war-steel specifications commands almost double price. Ordinary wire rods are quotable at $60, while $80 to $90 is being obtained for rods containing a little extra carbon and manganese. Ordinary rods at $60, moreover, are not cheap, as they are $2.70 per hundred pounds, while the regular market price of wire nails is $2.50 per keg of 100 pounds net weight of nails, with a keg costing about 15 cents thrown in. In the language of the street, "Can you beat it?"

Readers' Views and Comments

Power and Heat for Chemical Plants

To the Editor of Metallurgical & Chemical Engineering

Sir:—I congratulate you on your May 1 issue. There is plenty of inspiration to be found within its covers. Surely applied science is now thoroughly awake in our favored land!

I was especially interested in the papers and in the discussion on the subject of "Power"; the opinion being expressed that under the most favorable conditions, such as cheap coal, cheap transportation, abundant labor, etc., steam might now compete with Niagara power. This is in line with the suggestion I made in your March 15 number, with respect to which you were kind enough to make favorable editorial comment.

Now I desire to bring out a point, in this connection, which seems to have been overlooked; and which I regard of the greatest importance, to-wit: The *advantage* that steam may have over water power where there is a *fair balance* between the *steam heat a plant requires, as such*, and *heat for conversion into electricity*. The point I have in mind is this: That if it be assumed that 25 per cent of the heat units of the coal is required in the development of electric energy in an electrochemical plant employing steam; *then that plant should be developed for utilizing the remainder of the available heat units of the fuel* (chiefly in the form of the latent heat of the steam) in multiple-stage evaporating, etc. By so doing the electric energy required for the electrochemical work would be largely a by-product. There are many purely chemical operations where a large preponderance of heat over power is necessary.

Finally, it is conceivable that great plants where heat (at low temperatures) is king might well put in electric generators and thus obtain electric energy at very low cost. I think that some day we will have more regard for this principle of "balance." There are great industries in New York City and in practically all manufacturing communities, where the two great forms of energy, heat and electricity, might mutually complement each other. As the situation now stands, we have great central lighting and power stations wasting 75 per cent of the heat units of the coal in condensing the steam. And on the other hand, we have vast sugar refineries and other industries whose chief need is steam-heat. From a heat-standpoint they should operate in combination.

A. C.

Brooklyn, N. Y.

Testing Rubber Insulation

To the Editor of Metallurgical & Chemical Engineering

Sir:—In testing rubber insulation according to the Underwriters' Specifications, the writer found that samples taken from the same coil showed marked variation in strength and elongation. The wire had been in stock some time and the tests were carried out with the idea of putting it in with the new stock, provided the insulation had not deteriorated.

Samples 5 in. long were taken from each coil. They were rolled between two blocks of wood to loosen the insulation. The rubber could then be slipped off the wire. The insulating material was then tested for elongation, stretch and tensile strength.

The results varied as much as 100 per cent, and in only six coils out of fifty-two did the samples check.

The trouble did not lie in non-uniformity or deterioration of the rubber compound, as was first supposed. The method of separating the wire from the insulation was at fault. No matter how carefully the samples were rolled between the two blocks, the insulation could not be removed intact. In places it would stick to the wire.

A new method was therefore devised for removing the insulation. The wire was tinned copper. Tin amalgamates with mercury very easily and forms a very slippery surface on the copper. The mercury has no effect on the rubber compound. About 1/4 in. of insulation was cut off of each end of the samples and the stripped wire scraped to remove dirt and grease. The ends of the samples were then immersed in mercury. After a period of time, varying from four to twenty-four hours, the insulation could be slipped off the wire with almost no effort.

This method is being used by one of the largest electrical manufacturers in the country. Besides the accuracy and uniformity of results accompanying the application of this property of mercury, the cost of the testing has been reduced by over one-third.

Aaron Arthur Ladon.

Chicago, Ill.

Experiments on the Electrolytic Production of Hydroquinone

To the Editor of Metallurgical & Chemical Engineering

Sir:—It would seem possible to produce hydroquinone by the oxidation of benzol as well as by the oxidation of aniline, and electrolytic processes, if feasible, would offer the opportunity of obtaining a purer product than any process in which a chemical oxidizing agent is employed. Experiments along this line were moderately successful.

As benzol is a non-conductor, some electrolyte must be used to carry the current, and sulphuric acid seemed to be the cheapest and most satisfactory. The addition of alcohol to the benzol and acid produces a solution, thereby doing away with the necessity of stirring to emulsify, and, as was later noted, increases the yield of hydroquinone. The solution used was as follows:

Ethyl alcohol (95 per cent)	120 parts by volume
Benzol (C. P.)	40 parts by volume
Sulphuric acid (Sp. gr. 1.82)	10 parts by volume
Water	90 parts by volume

The electrolysis was carried out in a glass vessel, using hard carbon electrodes connected in the multiple system. Several runs were made, with different current densities, and at different temperatures.

The solution turns yellow after a few minutes of electrolysis and gradually gets darker, finally becoming a dark brown, probably due to the formation of tar. At the end of the electrolysis, the solution was filtered to remove the tar, a little water was added, and the excess alcohol and benzol distilled off; then boiled with animal charcoal to decolorize, and evaporated almost to dryness. Finally, more water was added, the solution boiled again for a few minutes, filtered to remove the charcoal, and the hydroquinone obtained by crystallization. The product was pure and very white, so that no further purification was necessary.

Low current densities produced the best results, probably due to the fact that the temperature was much lower because of the less I^2R heating effect. It was found to be of advantage to place the containing vessel in an ice-water bath. The best results were obtained

with a current density of about 1.5 amperes per square decimeter, an electromotive force of 5 to 6 volts, and at a temperature of 5 deg. to 10 deg. Centigrade, the average yield being about 25 grams per kilowatt-hour. No doubt there would be less decomposition of the product at even lower temperature, but the increase in resistance of the solution would offset this advantage. Neither anodes nor cathodes were attacked in the least as far as could be determined.

This process seems worthy of further investigation, especially to find some method of preventing the formation of tar during electrolysis, and to increase the current efficiency. The simplest explanation of the reaction is the oxidation of benzol by the oxygen produced at the anode by the electrolysis of sulphuric acid. $C_6H_6 + O_2 = C_6H_4(OH)_2$. The alcohol may act catalytically, or may simply have the effect of bringing the molecules of benzol into more intimate contact with the anode than would be possible in the case of an emulsion of benzol and acid, even with vigorous stirring.

A. R. GREENLEAF.

Wakefield, Mass.

The Western Metallurgical Field

Use of Slide Rule in Calculating Base-Bullion Assays

The assay of base-bullion is a comparatively simple metallurgical process; but in the course of its evolution from an unreliable and varying assay to a remarkably trustworthy and uniform one, lengthy and tedious calculations have been required. The following notes will serve to trace the steps of the evolution referred to and show the expedients which have been devised at one of the Denver laboratories to overcome the tedious calculations that formerly were necessary.

Neglecting the step of cupellation, which is the same under any scheme of preparing the buttons and calculating the final result, base-bullion assaying has progressed through five distinct stages or methods of procedure.

1. The sample of from 5 to 7 pounds, however obtained from the lot it represents, is melted and cast into a mold about 5 in. wide by 7 in. long. The bar thus formed is cut longitudinally into halves, one of which is reserved and the other assayed. The manner of taking the individual cuts from the second half is determined by a template locating four areas as shown in Fig 1, the slugs being cut from the bar and clipped to

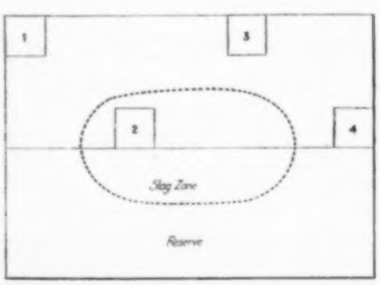

FIG. 1—TEMPLATE FOR BASE BULLION SAMPLES

weigh exactly ½ A.T. Due to the position of these points relative to the slaggy zone and to the more rapidly cooled sides, the resulting assays vary widely as shown by the following typical figures.

No.	Weight of Button	Oz. Ag Per Ton
1	110.02	220.04
2	108.10	216.20
3	109.70	219.40
4	109.26	218.54
Average	109.27	218.54

The four corresponding gold assays will show much greater divergence, increasing with the richness of the bullion.

This method gives the least accurate determination of the value of the bullion, but offers the simplest calculation. Since the slugs are cut to weigh exactly ½ A.T., it is necessary only to multiply by two the weight in milligrams of the cupellation bead.

2. The lot sample, however obtained, is melted, and "gum drops" are cast therefrom by using a small ladle and conical mold. Each of the "gum drops" weighs slightly over ½ A.T., and is clipped to exactly that weight for cupellation. The resulting procedure and calculation are the same as in cast 1. This method gives a greater uniformity of individual assays and a more accurate determination of the bullion value, with a simple method of calculation.

Gum Drop	Weight of Button in Mg.	Oz. Ag per Ton
1	109.20	218.40
2	109.15	218.30
3	109.40	218.80
4	109.35	218.70
Average	109.275	218.55

3. The lot sample is made into "gum drops" as in case 2, but instead of clipping to an exact weight of ½ A.T., each drop is weighed whole with ordinary gram weights, and the weight converted into the corresponding A.T. equivalent. The silver bead is weighed in milligrams, and the assay calculated by proportion arithmetically or by the aid of logarithms. This method gives the most accurate determination of the bullion value, but involves the most lengthy and tedious calculation.

Weight of Gum Drop in Grams	Weight of Button in Mg.	Oz. Ag per Ton
14.18	106.2	218.44
13.72	102.8	218.53
15.15	113.6	218.69
14.15	106.0	218.49
	Average	218.54

14.18 : 106.2 : : 29.166 : (X) 218.44

4. The lot sample is melted and made into gum drops as before, and each is weighed whole by means of decimal A.T. weights. The silver beads are weighed in milligrams. This method gives as accurate a determination of bullion value as in case 3. The calculation is simpler, obviating the conversion of the weight of the gum drop from grams to A.T., but it still involves one long division for each button.

Weight of Button in Milligrams		Weight of Gum Drop in Decimal A. T. Weights		Oz. Ag per Ton
106.2	÷	0.4861 +	=	218.44
102.8	÷	0.4704 +	=	218.53
113.6	÷	0.5194 +	=	218.69
106.0	÷	0.4851 +	=	218.49
			Average	218.54

5. The lot is sampled and the gum drops and silver beads are weighed as in case 4. The calculation is made with a 20-in. slide rule. This method gives the same degree of accuracy in determining the bullion value, and affords a very simple, rapid and sufficiently accurate method of calculation.

Weight of Button in Mg.	Weight of Gum Drop in Decimal A. T. Weights	Oz. Ag per Ton Slide Rule Calculation	Oz. Ag per Ton Arithmetical Calculation
106.2	0.4861 +	218.5	218.44
102.8	0.4704 +	218.5	218.53
113.6	0.5194 +	218.8	218.69
106.0	0.4851 +	218.5	218.49
	Average	218.57	218.54

A further illustration comparing the slide rule and arithmetical results on a lot of eight gum drops is given below.

	By Slide Rule	By Arithmetic
	172.6	172.7
	171.8	171.9
	171.8	172.0
	172.2	172.3
	172.2	172.3
	171.5	171.5
	172.2	172.2
	172.2	172.1
Average	172.06	172.12

Since an accurate assay of base bullion requires from 4 to 16 cupellations for each lot, depending on the grade and purity of the bullion, the accuracy of the determination is affected by the methods of procedure outlined above. In the old short methods, 1 and 2, accuracy is sacrificed to simplicity of calculation. In 3, we gain accuracy only through such tedious calculation as to prohibit the assaying of a large number of samples within the time that can be given such work by the assayer. By method 5, however, accuracy of assay and simplicity of calculation are combined to great advantage. Decimal A.T. weights reading to 0.0002 A.T. can be procured from weight manufacturers, and the 20-in. slide rule read under a large magnifying glass gives results well within the limits of accuracy of cupellation. The method is in successful use in umpire work on Western lead bullions.

Accidents at Metallurgical Works

For the first time since its organization the Bureau of Mines has made a report on accidents at metallurgical works, covering smelting, milling and refining plants for gold, silver, copper, lead, zince and quicksilver, and iron-ore washers. Iron blast furnaces are not included. The report, issued as *Technical Paper* 124, is for the calendar years 1913 and 1914, during which time 119 men were killed, 2285 seriously injured and 11,046 slightly injured. These figures represent fatality and injury rates of 1.55, 29.67 and 143.44, respectively, per 1000 men employed.

An arbitrary classification of slight and serious injury was made on the basis of time lost by the injured man, 20 days being the dividing point. This basis will be changed for the 1915 report to conform with the classification adopted in the States now having compensation laws, as follows:

1. Fatal.
2. Serious (time lost, more than 14 days):
   (a) Permanent disability.
      Total.
      Partial.
   (b) Others.
3. Slight (time lost, 1 to 14 days, inclusive).

The statistical tables given in the report show a lower accident rate in ore-dressing plants than in smelters. Classified according to causes, the accidents appear as follows:

	Ore-Dressing Plants			Smelting Plants		
Cause of Accident	Killed, Per Cent	Seriously Injured, Per Cent	Slightly Injured, Per Cent	Killed, Per Cent	Seriously Injured, Per Cent	Slightly Injured, Per Cent
Haulage	12.8	9.6	6.9	25.0	14.0	9.7
Machinery	25.6	28.9	16.5	18.7	9.0	5.7
Falls of persons	15.4	16.0	12.4	20.0	13.8	9.5
Suffocation in ore bins	7.7	...	.1	3.7	.2	.1
Flying or falling objects	15.4	16.0	23.8	5.0	14.7	17.1
Electricity	7.7	1.7	1.4	5.0	.6	1.2
Hand tools	..	5.3	10.5	...	6.9	10.9
Nails, splinters	..	1.1	5.1	...	.3	2.1
Burns (steam, water, matte, slag)	..	1.0	1.0	11.3	26.7	20.6
Other causes	15.4	20.4	22.3	11.3	13.8	23.1

The greater use of machinery in mills than in smelters undoubtedly explains the relative figures in that item, for in the former the men are in closer contact with jigs, tables, stamps, rolls, crushers, belts, wheels and shafts. In other items the figures are reversed, due to the prevailing conditions. The report serves a useful purpose in directing attention to the cause of accidents and will serve as a guide for improving conditions.

Symposium on Flotation

At the flotation conference held at Lawrence, Kan., Jan. 28 and 29, 1916, the proceedings of which were reported in this journal Feb. 15, a questionnaire on flotation was formulated as a basis for a proposed symposium on the subject at the Arizona meeting of the American Institute of Mining Engineers next September. These questions are designed to bring out information on the theoretical and practical phases of flotation, either by way of formal papers, discussion or suggestions for research. By giving publicity to the matter well in advance of the meeting, it is hoped that the symposium will be a marked success. The questionnaire follows:

Practical questions:

1. What is the effect of dilution of a pulp with water on the flotation of the minerals contained?
2. Is agitation of a pulp necessary for all froth flotation?
3. Is there a fundamental difference between "pneumatic" froth and "mechanical" froth?
4. Are ores that produce much finely divided, or flocculent material, harder to treat successfully by flotation than those which do not contain much of this "colloid" material?

Questions on Oils.

1. Is an "oil" necessary for froth flotation?
2. What is the effect of the addition of an excess of flotation oil?
3. Upon what does the necessary quantity of oil depend—the quantity of sulphide minerals present, the amount of air entering the froth or the amount of water present relative to the ore?
4. Is the function of oils to cause selective adherence of air bubbles to sulphides or is it to assist in the formation of a froth?
5. Are the bubbles in a froth mantled with oil or is it sulphide minerals which are coated, or is the effect of the oil in some way connected with modification of various properties of the water?
6. Is it the soluble or the insoluble portion of an oil which assists frothing?

Theoretical Questions.

1. What is the real effect of other addition agents, such as alkalies, or acids, or copper sulphate in the flotation of sphalerite?
2. In what way can surface and interfacial tensions explain froth flotation?
3. How can electric charges on minerals explain flotation?
4. Has "flocculation" (as applied to colloids) anything to do with flotation?

Flotation of Copper Ore in Canada

The Sable River Mining Co. is reported to be the first to install a Callow flotation plant for the treatment of copper ores in Canada. The company's property is near Massey, west of Sudbury. The ore is chalcopyrite containing 3 per cent copper and is said to float readily. The oil mixture is wood creosote, crude turpentine and pine oil with a small amount of coal tar and coal tar creosote. The plant will have a capacity of 50 tons per day and is intended to treat reground tailings from Wilfley tables.

Renewed Activity in the Tungsten Mines at Atolia, Cal.

The rise in price of scheelite, one of the five tungsten ores, has built up what is said to be one of the largest tungsten camps in the world at Atolia, Cal., which is 60 miles from Barstow out on the Mojave desert. There are three tungsten districts in the vicinity, the Atolia, the Stringer and the Rand. The latter has been a steady producer of gold for 30 years and only recently have the properties been worked for tungsten. The Atolia district is 3½ by 10 miles in area and in December the main camp consisted of only a few tents. Recent interest in the development of the properties has been

such that at the present time the population is estimated at more than 2000. Three carloads of high-grade ore were shipped during the fourth week in April by the Atolia Mining Company and plans are now under way for remilling the dump of this company, which has been accumulating for many years and which contains 5 per cent ore. It is estimated that at prevailing high prices $3,000,000 worth of metal can be extracted from the dump. Just what price the company secures for the metal is not known, but $5 per pound has been suggested as an approximation.

Non-Ferrous Metal Market

Wednesday, May 10.—The outstanding feature in the market during the last two weeks has been the sensational rise in the price of silver, which advanced over 10 cents since our last report, due to demand from Europe and the Far East for coinage purposes. During the last few days, however, it has reacted somewhat from its high mark of over 77 cents. The other metals have either remained stationary or have registered short declines, due to dullness in most cases.

Copper.—Copper prices have remained practically stationary during the last two weeks, although it was the strongest metal on the list outside of silver and was in marked contrast to spelter, lead, tin and antimony. The exports for April were 21,000 tons. It is understood that very little copper is available even for the last quarter. The American Metal Market report gives the quotations as follows: Prime lake, 29.75 to 30.25; electrolytic, 30.50 to 31.00; casting, 27.75 to 28.25.

Tin.—Futures have been in good demand, while the spot market has been comparatively dull. Dealers have been disinclined to sell on account of the uncertain future of the market. The obtaining of shipping permits is difficult and is one of the main controlling factors in the market. Straits tin is quoted at 49.75 spot.

Lead.—The lead market has been very dull and has brought out some cheaper offerings by second hands. The Trust price is still 7.50 cents, while outside prices are 1/8 to 1/4 cent lower.

Spelter.—Spelter has been dull and has declined about 1 cent per pound. The market is spasmodic as regards buying and no sustained demand has occurred. May spelter is quoted at 16.75, June at 16.25 and third quarter at 15.05 to 15.30. Spot quotations are 16.93½ to 17.17½.

Other Metals.—*Antimony* has been very dull and has declined 4 cents to 36 cents. There have been quite a few sellers, but customers have not shown a disposition to buy. *Platinum* remains nominally quoted at $85.00 and *silver* is now at 73¼ cents, 4 cents below its high point on May 3. *Mercury* has dropped further, to $110 per flask.

The Iron and Steel Market

The general trend of steel prices is still upward, but the rate of advance is very slow, there being only sufficient advances to show that the market is strengthening rather than losing ground. As a matter of fact steel prices are not at this juncture a good index to the state of the steel market or the prospects of the trade. A better index is the pressure upon the mills for delivery of material already contracted for, while the future of the trade hinges largely upon the supply of workmen and their willingness to do a full day's work each day, in both the steel-producing and the steel-consuming industries. Another element that will help to shape the future course of the steel trade is transportation, the ability of the railroads to carry the freight offered.

While practically all steel products advanced sharply during February and March, the advances since April 1, for deliveries at mill convenience, have been only sporadic. In April sheets advanced $1 a ton, tin plate 50 cents a box and pipe and boiler tubes $4 a ton and more, according to size. May 1 plain wire advanced $4 a ton and wire nails and barb wire $2, while since then tin plate has advanced another 50 cents a box. Some of the mills have stiffened in their plate quotations, the Carnegie Steel Company having adopted 2.90c. as its regular quotation.

Labor Troubles

The unrest in the ranks of labor has steadily increased, and this has taken the particularly unfortunate turn of men demanding a shorter workday at a time when there are not enough men to do the work in hand if all worked the customary hours. Strikes on May 1 for an eight-hour day for machinists were not as general as labor agitators had expected, but were serious nevertheless. The machinists employed at the East Pittsburgh plant of the Westinghouse Electric & Manufacturing Company struck late in April, and early in May unorganized mobs of strikers and others began raiding various industrial plants in the neighborhood for the purpose of forcing men to strike. The most violent attack was made upon the Edgar Thomson Steel Works at Bessemer, the mob being confronted at the entrance by a heavy guard, who fired and killed two or three men, wounding others. The militia was called out and restored order. The Westinghouse strike itself is now practically over, many men returning to work at rates formerly prevailing.

The wage advance in the steel industry, averaging about 10 per cent, went into effect May 1, except that the advance in the Connellsville coke region became effective May 8. Labor in the steel industry is fairly well satisfied, but the supply is insufficient. In the steel-consuming industries it is likely there will be strikes at various points as long as the industrial pressure continues. It is a question whether either the production or the consumption of steel can be maintained at the rate the orders on books and the physical capacity of plants would permit, but whether the trouble will be of such a nature as to make steel more plentiful or more scarce cannot be forecast.

The inadequate supply of labor in the steel industry affects the work upon steel mill extensions much more than the operation of plants already in existence. Construction work is proceeding much more slowly than was expected. The general statement is made that work on by-product coke ovens has been proceeding slowly, that practically all the jobs are three months or more behind schedule. Much the same statement could probably be made with respect to additions to steel-making capacity.

Greater Pressure for Steel Deliveries

Activity in the far forward deliveries has decreased farther, and the market in this respect is extremely quiet. Confronted with prospects of so much labor trouble both producers and consumers of steel are chary about making commitments for the far future. Consumers are certainly exerting more pressure upon mills for delivery of steel already bought, but whether this is because more steel is needed for ultimate consumption or because buyers fear that they may not be able to fabricate it as well later, or that the mills will not be able to produce later at their present rate, can scarcely be determined in the confused state of affairs in the trade.

Pig Iron

Apart from a recent drive made by Buffalo furnaces, whereby a large tonnage was disposed of at slight cuts from prices formerly ruling, the pig iron market has been extremely dull in practically all sections. Prices have not yielded elsewhere, and may be described as firmly maintained despite—or perhaps because of—the lightness of inquiry.

Expectations entertained for many weeks in certain quarters that a buying movement would develop in pig iron, and disclose a shortage in productive capacity as compared with consumptive requirements, continue to be disappointed. It seems now to be well established that the country cannot make more pig iron than it has been making lately, the rate being a shade under 40,000,000 tons a year, and production may indeed decrease as warmer weather arrives. The expected increase in steel mill requirements has not developed. The abnormally heavy production of scrap is assigned as one cause, but another may be that work on steel plant extensions is proceeding slowly and additional pig iron is not likely to be required as soon as expected. We quote No. 2 foundry iron, delivered Philadelphia, \$20.25 to \$20.75; f.o.b. furnace, Buffalo, \$19 to \$19.25; delivered Cleveland, \$19; f.o.b. furnace, Chicago, \$19; f.o.b. Birmingham, \$15 to \$15.50; f.o.b. valley furnaces, 95c. higher delivered Pittsburgh; Bessemer, \$21 to \$21.50; basic, \$18.25 to \$18.50; foundry and malleable, \$18.50 to \$19.

Unfinished Steel

There has been a slight increase in offerings of soft steel billets and sheet bars, but with the market not quotably changed, what are regarded as regular prices being \$45 for Bessemer and \$45 to \$50 for open-hearth, with rods at about \$60. High-carbon, forging and war specification steels all show a further advancing tendency. There is a fairly heavy inquiry for shell steel for delivery throughout 1917, quite out of keeping with some recent predictions on this head. Forging billets are quotable at \$65 and upwards, while war billets might bring as high as \$90. High-carbon rods have sold up to \$90.

Finished Steel

Regular prices, for delivery at mill convenience, are 2.50c. on bars and shapes and 2.75c. to 2.90c. for plates, plates for prompt shipment ranging up to 4c. Sheets, particularly blue annealed, have advanced a trifle. Wire prices were officially advanced May 1 by \$2 a ton on nails, polished staples and barb wire and \$4 a ton on plain wire, both bright and galvanized. Nails are now on the basis of \$2.50, but some producers are quoting \$2.60.

Award of Willard Gibbs Medal to Willis R. Whitney

The Willard Gibbs Medal has been awarded to Dr. Willis R. Whitney, director of the research laboratories of the General Electric Co., Schenectady, N. Y. The medal was founded by William A. Converse of Chicago and has been presented to four other prominent chemists. Presentation will be made at the meeting of the Chicago Section of the American Chemical Society, on May 19, when Dr. Whitney will make an address on "Incidents of Applied Research."

Society of Chemical Industry.—On Friday, May 19, Dr. Raymond F. Bacon, director of the Mellon Institute, Pittsburgh, will lecture before the New York section on "Some Problems of the Petroleum Industry."

Nitre Cake in Sulphate of Ammonia Manufacture

Some interesting data on using nitre cake as a substitute for sulphuric acid in the manufacture of sulphate of ammonia are given in *The Iron and Coal Trades Review* (London), April 14, 1916. The data are taken from recommendations made by the (British) Sulphate of Ammonia Association. The use of nitre cake is only advocated as a temporary expedient since it is not deemed advisable to reduce the percentage of ammonia in the sulphate to under 25 per cent. With the use of nitre cake the percentage is 24 or less. The recommendations are based on the practical experience gained at a large works which used nitre cake on a working scale over a considerable period; it will be seen that there are dangers to be guarded against, which are not apparent in mere theoretical or laboratory work. The average composition of the salt produced at the works in question was: Ammonia, 24.01 per cent; free acid, 0.88 per cent; moisture, 2.70 per cent; Na_2SO_4, 3.20 per cent, corresponding to a consumption of over 7 per cent of nitre cake, equal to about 2½ per cent of acid saved.

There are two sources of nitre cake: (1) From sulphuric acid plants; (2) from nitric acid plants. The nitre cake from the first source usually contains 20-35 per cent of free sulphuric acid with traces of nitric acid, and from the second source 30-40 per cent free sulphuric acid, and up to 2 per cent or even more of nitric acid. The presence of free nitric acid causes serious damage to the lead work of the saturator, and ultimately destruction of ammonia, and too much care cannot be taken in guarding against the presence of this substance. The danger is emphasized at the present time, when nitric acid plants are very hard pressed, and it is not profitable to the nitric acid manufacturer to remove the last 1 or 2 per cent of nitric acid from the nitre cake. The maximum percentage of nitric acid in the nitre cake used by sulphate of ammonia makers should be 0.05 per cent.

The use of a quantity of nitre cake exceeding 10 per cent by weight of the acid except in special circumstances is not recommended. The nitre cake should be dissolved in water until the solution shows 48.5 deg. Bé. at 200 deg. F. Mother liquor from the saturator may also be used for dissolving the nitre cake. This solution must be run into the saturator as hot as possible, and continuously with the acid. The best working strength is 41.5 to 43 deg. Bé. and the salt produced will vary from 23 to 24 per cent ammonia. With the solution of nitre cake in water of the strength mentioned above, one volume of solution should be used with every ten volumes of 70 per cent chamber acid; or its equivalent.

The difficulties encountered when using large quantities of nitre cake are as follows: (1) Precipitation of sulphate of soda on adding the nitre cake to the saturator. This causes the production of an irregular quality of salt containing anything down to 15 per cent ammonia. (2) Irregular working of the bath owing to the impossibility of control without frequent titration. The latter is not possible at the present time. The salt produced often contains 2 per cent of acid after leaving the centrifugal machine, and in this case moisture is absorbed in store, and it is not possible to pack the product in bags. When the quantity of nitre cake used is less than 10 per cent by weight of the acid, these difficulties are partially overcome.

Manufacture of Sodium Hydrosulphite in the Sugar Factory.—The following data on hydrosulphite of soda are taken from *The Chemical Trade Journal and Chemical Engineer* of April 22, 1916. Hydrosulphite of soda,

$Na_2S_2O_4$, which previous to the war was sold as a white salt under the trade name of "Blankit," and manufactured by the Badische Anilin und Soda-fabrik, is a powerful bleaching agent, the use of which seems now well established in the sugar industry. Although it may be true that it has not entirely realized all the advantages predicted of it by its makers at the time of its first appearance on the market, there appears to be no doubt whatever that it is a most valuable decolorizing agent in the manufacture of white sugar. Since the outbreak of the war, hydrosulphite of soda in the form of powder appears to have been unobtainable, excepting in small occasional quantities and at extortionate prices, and it is certain that white sugar manufacturers in different parts of the world have felt keenly the deprivation of this commodity.

It is therefore a matter of much interest, says the *Int. Sugar Jour.*, to announce that M. Louis Deschamps, a well-known French chemist, after some years of experimental work, has now evolved a process which can be installed in the sugar factory or refinery for the manufacture of the bleaching agent in the state of solution ready for use. The plant used is comparatively simple, and for its operation the supervision of a chemist is not necessary, the services of an intelligent workman only being required. The principle of the method is first to obtain hydrosulphite of zinc, which is readily done by acting on metallic zinc with a solution of sulphurous acid.

By treating the solution of hydrosulphite of zinc thus formed with caustic soda, a solution of hydrosulphite of soda results, which procedure is illustrated by the following equations:

$$Zn + 2\ SO_2 = ZnS_2O_4$$
$$ZnS_2O_4 + 2\ NaOH = Na_2S_2O_4 + ZnO + H_2O.$$

Whereas formerly, liquefied sulphur dioxide was necessary for the process of manufacture, this product (largely of German origin) is now no longer indispensable. Ordinary sulphur oven gas being inadmissible for the purpose, owing to its content of free oxygen, M. Deschamps has devised a special oven producing sulphurous acid gas quite free of oxygen, though containing nitrogen, which is an inert gas not interfering in any way with the reaction. It is the invention of this oven that renders the process of making hydrosulphite a practical one in the tropics, since it obviates the necessity of using liquefied sulphurous acid gas in cylinders, which are both costly and difficult to transport.

American Carbide Plant to Be Built in Norway

The Union Carbide Company, Niagara Falls, has started the erection of a large calcium carbide plant at Saude, about 60 miles from Bergen, Norway. The plant will buy its power from the Aktieselskabet Saude Faldene, and the power is to be furnished beginning Jan. 1, 1918. In the meantime the plant will be constructed. At first 20,000 hp. will be used. This will later be increased to 40,000 hp. The company's American and Norwegian engineers from this country will go over to superintend the construction.

One reason for the establishment of the plant in Norway is that much cheaper power can be obtained than in this country. Cheap labor is also available, and under normal conditions cheap freight rates can be obtained. The company plans to take care of its export business from this plant, and also its coast business in this country. In other words, carbide can be made over there and shipped back here cheaper than it can be made here.

Research and the Newlands Bill

BY WILLIS R. WHITNEY

For a good many years our colleges have been teaching their students the arts and sciences, and more lately, even preparing them for routine service in the technical industries. But for over two-score years Germany has carried education a step further. In our institutions of learning we devote most of our efforts to the undergraduates, bringing them up to a certain limited, but useful state of development. We have failed to prepare any considerable number of men for advanced scientific work, and have neglected the need for extending the boundaries of scientific knowledge. For this reason we, together with many other countries, have had to depend on German Universities for the training of our research workers and teachers. Going to Germany for the doctors' degree has had reason behind it.

The picture accompanying this note was taken in 1856, at the Goettingen laboratory of Professor Woehler. It shows advanced students of chemical research from many lands. Two or three of them are Americans.

WOEHLER'S RESEARCH STUDENTS 1856

Under Woehler's direction were carried out the first successful experiments on the production of organic compounds from laboratory products. These experiments opened the way for all the subsequent organic syntheses; dyes, medicines, rubber, and many thousands of useful products. Woehler also produced the first metallic aluminium, now made in this country at the rate of 30,000 tons per year.

The picture shows but one of the successive groups of men who came under Woehler's influence. And Woehler was but one of the scores of scientific leaders who made possible Germany's phenomenal industrial and manufacturing development. How many such groups of advanced students can be found even at this late day in America?

We should do all we can to bring about the establishment of this kind of effort in our United States. It could be done as it has been done in so many cases in Germany, by encouraging the scientific men of our colleges. Most of them are now so exhausted by undergraduate teaching, and discouraged by financial conditions, that research seems impossible. When we recall the successful teaching and research work of such men as Liebig, Woehler, Ostwald, Nernst, Roentgen, Hertz, Van't Hoff, Haber, Wien, Fischer, Baeyer, Bunsen, Kirchhoff, Helmholtz, and many more, who were teachers of the sciences, but also active workers in them, we must deplore the short-sighted method of confining our

scientists to teaching, to the entire exclusion of the practical experimental work demanded by our need for new knowledge. Consider the sheer waste of intellect. There is no other field calling so acutely for conservation. And the nation needs what these men might give it. Thus far we have been depending upon others to produce the new knowledge, trusting to the gleanings of their harvest to furnish us seeds for a second crop of mechanical inventions and adaptations, forgetting too long that growth and continued prosperity come only to those nations which are responsible for the original research work, and not for the storage or conservation of knowledge.

The most natural and economical way of attempting to improve our national condition in this respect would be to encourage our college professors of the sciences—physics, chemistry, electricity, mechanics, etc.—to do research work, to gather about them groups of post-graduates, who would co-operate in the lines of experimental work which the knowledge or interest of the particular teacher dictated. A very few are already doing this, but it is only in biological research that the activity is very noticeable.

The Newlands bill No. 4874, providing for the establishment of an "engineering and mechanics' arts" experimental station in connection with the Land Grant College of each state, seems to be a start in the right direction. It is planned thereby to do for the industries what has already been done by similar bills for agriculture. The plan has been highly developed, and proved very successful in the latter field. This bill seems to be a constructive, active attempt to do something far-sighted for the future welfare of our country, and is certainly a part of wise preparedness. It should discover and bring forth a great deal of the separated and remote scientific talent of the country, and assist it to work along the lines best suited for producing new knowledge, trained investigators, and inspired teachers. By effective co-operation under the supervision of a federal department it should lead to well advised efforts in the arts without that duplication which is now a drawback of isolated research. The plants exist in the present colleges, together with a picked class of men. Hence there is economy in the plan proposed by the Newlands bill.

It seems to me probable that if federal aid were given the Land Grant Colleges for this purpose, there would take place what occurred when this was done for Agricultural Research. The separate States seeing the advantages, and realizing that a start had been made, would also give aid. In 1913, the federal appropriation for agricultural experiment stations amounted to $1,545,000, and additional financial aid rendered by the States aggregated $1,807,016.

Of the agricultural work accomplished, Dean Bailey of Cornell, has written:

"In 1887 Congress passed a bill providing that $15,000 in money be appropriated to each State for the organization and conduct of an experiment station in connection with its agricultural college. Two facts had become painfully apparent. One was that the lands of the original grant had been largely wasted, and the other, that agriculture lacked a body of exact scientific data on which to establish courses of reliable instruction. Accordingly, the Hatch bill appropriated money instead of lands, and made rigid provisions for its expenditure along agricultural lines and for research only. In spite of the utmost precautions some of these funds were absorbed in teaching by institutions still embarrassed for funds, and by men who scarcely knew the meaning of research, or if they did, were ignorant of how to conduct it.

"But in time, and even in a surprisingly short time, results began to appear. There were men who knew how to discover the laws on which plant and animal growth depend, and those on which the soil produces, and gradually the scientific principles underlying agricultural practice began to be established. Moreover, these principles worked when tested out in practice, and for the first time, young men fresh from college, but in possession of these principles, succeeded better than had their fathers, though to the art and manner born. That was what made agriculture respectable in the university, and about 1905 the subject had gained a permanent standing in some of the best of the State Institutions, which means that at last it was, alongside other great fields of inquiry, challenging the abilities of the best scholars of the times."

President Thompson of the Ohio State University said: "The experience and history of the land grant colleges have brought industrial education to its rightful place in the esteem of the American people, and have forced its recognition by all institutions of higher education."

The day upon which a similar statement may be made concerning scientific research in general will see our country far advanced upon the road that leads to assured National Preparedness. For the only safe and sane preparedness must rest upon that broad and thorough development of the industries which is impossible without a constantly extending knowledge of scientific fact.

Corrosion of Condenser Tubes

No conclusive results, but interesting isolated data are brought out in the third report of the Corrosion Committee of the Institute of Metals (London) presented in abstract at the annual meeting March 29, by Mr. W. E. Gibbs and further abstracted in *Engineering* March 31, together with the discussion. The committee tested five different alloys furnished by the Broughton Copper Company and the Muntz Metal Company. One of the alloys, a phosphor-bronze, contained 3.8 per cent zinc and 0.02 per cent phosphorus, and another aluminium-copper contained 7.92 per cent aluminium, 0.25 per cent iron, and 0.13 per cent silicon. The other alloys were brasses.

One novel point brought out in the new research was that the action of stagnant sea-water varied with the depth of immersion owing to corresponding variations in the air content. Dr. Bengough, immersing his specimens to a depth of 1 in., had found spots of oxychlorides on the upper surface. With the 3 in. immersion adopted by the speaker no such spots were developed. The most important point established was that the dezincification of the brasses in sea-water depended on three things—viz., the aeration, the dilution, and the CO_2 content. The experiments made with pure copper and pure zinc bore out the observations made on the two as alloyed. Aeration of the water in condensers arose from eddies at the mouth of the tubes. Just inside the tube-plate there was thus a "churning" point at which corrosion was marked, and especially in low-temperature tests.

It would appear that the solution of copper in sea-water depended very largely on the dissolved salts and was reduced by dilution. With zinc, on the other hand, the rate of solution increased as the concentration diminished, being greatest in distilled water. Carbon dioxide, moreover, played an important part in the solution of zinc. In the absence of CO_2 there was practically no solution of zinc in sea-water saturated with air, whilst the process was rapid in sea-water free from air

but saturated with CO_2, and brass behaved similarly. The formation of the oxychlorides depended on the range of temperature and on the concentration of the salts.

It had been proved that local electromotive forces, due either to temperature differences or local variations in composition, played a large part, and an important point for settlement was the discovery of what protective electromotive force sufficed to afford security. He had tried the effect of coke, and found that Mr. Arnold Philips was right in the view that its presence might accelerate the solution of the zinc. In practice, however, the conditions in which it might act thus, could seldom arise, as the contact would be generally too poor, both with the metal of the tube and with the sea-water, owing, in the latter case, to the tendency of the pores to get filled with non-conductive deposits. The tests indicated that hard-drawn metal lost weight less rapidly than annealed, but it was more prone to localised attack.

The discussion was opened by Mr. Arnold Philip, who observed that the report was a somewhat monumental document, difficult to discuss, and he hoped that in a later publication it would be possible to marshall the facts in a more attractive form. He suggested that the losses should be expressed as weights lost per square centimeter per unit of time. In their references to aerated sea-water the authors did not make it clear whether the oxygen was dissolved throughout the mass or whether it existed as bubbles. All sea-water contained dissolved oxygen to a considerable amount, and if this were removed very different results would be recorded in corrosion experiments. He agreed that oxygen in the shape of bubbles did have a large effect at what the author called churning points, and it was well known that troubles arose from this cause near the entrance to condenser tubes. The proposal to clean tubes *in situ* with weak acid was new to him, and he would like to see it tried, but on someone else's condenser. The suggestion was a novel one to him, and he would ask whether the authors had any experience of the method.

Mr. S. Smith said the dezincification of brass had been treated with an air of mystery, but the phenomenor was wholly at one with the general behavior of solid solutions. So far back as the eighth century Geber knew that silver could be selectively dissolved from a combination with gold. He could not help thinking that progress would be more rapid if the committee could get away from the study of actual condenser tubes and study the corrosion of the zinc and copper alone. He noted a start in this direction had been made, and he thought this was vitally important. He might add that he had himself found that the rate of solution of silver was greatly modified by the size of the crystal grains. He had noted the same thing in copper, and the difference was accentuated by cold working. With zinc the effect was less marked.

Prof. H. C. Carpenter noted that the copper-aluminium alloy used contained 7.92 per cent of aluminium. It was thus very near the saturation point of the alpha solid solution, and, in fact, in the cast state would contain some beta. On annealing this disappeared, but he should like to know if any were visible in the microstructure of the tubes used? If the metal was not in thermal equilibrium, then a reduction of the aluminium would probably lead to improved results, as the rate of corrosion of two-phase systems was generally greater than that of single-phase ones. The tabulated results seemed to show this alloy to be superior to all three brasses, while the phosphor-bronze came last; yet Mr. Gibbs recommended that which, on the face of it, appeared decidedly the worst. The fact appeared to be that no one alloy was the best in all conditions, and in the absence of special protective measures, not one would be suitable for all waters and all temperatures. The copper-aluminium tubes came out exceedingly well, but containing only 8 per cent of aluminium, the first cost would obviously be higher than that of brass tubes, and the important question was whether this difference would be great enough to prevent the use of the alloy as a substitute for brass.

Dr. W. Rosenhain did not agree with Professor Carpenter that the copper aluminium alloy would be improved by a diminution of the aluminium. The remedy for troubles arising from free air was to avoid negative pressures throughout the system. As to accelerated tests, he believed they had their uses, but there was a tendency to adopt them and swallow the resulting observations wholesale and without discrimination. With respect to experiments on the corrosion of zinc, it should be borne in mind that this metal had transformation points at relatively low temperatures, and its actual properties depended largely on its past history, so that on working with it a good deal of care was necessary to make sure of its real condition.

Sir Alfred Yarrow, called upon by the president, asked if the authors of the report had noted any effect due to the speed of the water flow. The experience of his firm had led them to believe that corrosion was much more rapid with low water speeds than with high, and they recommended engineers accordingly to keep up the speed of the circulating pumps, even when a boat was traveling at cruising speeds. The point was of importance, as the rate of corrosion of the tubes often determined the distance the boat could run before being laid up for repairs. He should like to know, therefore, whether he was right in believing that there was less corrosion with a rapid flow of water.

Mr. John Christy said there had been serious trouble with tube corrosion at the plant in his charge. Sea-water was used for circulating purposes, and the tubes gave out in twelve to eighteen months. The cost of replacement amounted to about 1000*l.*, less the value of the scrap. He had tried to protect them by means of zinc, but with only partial success. The zinc was costly to replace and required constant attention, since it was ineffective unless kept clean. He had consulted many leading authorities, and had recently adopted the process which was to be described that evening in Mr. Cumberland's paper. So far this had proved very satisfactory. In this method the electromotive force of the little electrolytic couples responsible for the corrosion was drowned out by a counter electromotive force supplied from an outside source. He had, as stated, found the method very satisfactory so far, and he hoped that the process would be thoroughly investigated by the corrosion committee. He agreed with Sir Alfred Yarrow that the corrosion was worse at low-water speeds.

Mr. Rolfe, who followed, observed that it was a *sine quâ non* that remedies for corrosion should not diminish the efficiency of the condenser, and certain of the recommendations made in the report must be regarded from this standpoint. The rate of flow which it was possible to adopt for a condenser was severely restricted. If not enough water was put through, the top tubes became ineffective, while if the quantity was too large, the cost of pumping became too high. There was thus some intermediate rate of supply which best suited the conditions. In power-station practice, with condensing water entering at 65 deg. Fahr. and leaving at 84 deg. Fahr., the quantity supplied was about 55 lb. of condensing water to 1 lb. of condensate. In all condensers, moreover, the velocity of flow must exceed a certain critical value. If below this, the water flowed through without turbulence, with the result that there was a

cold core in the center of the tube and a hot outside layer. In practice the velocity ranged from 4 ft. to 8 ft. per second. Applying these considerations to the recommendation to substitute parallel for series flow in condensers, this would mean that if the same quantity of water were sent through a four-flow condenser, the velocity would fall too low. The result would be a bad vacuum and a great loss of efficiency. If, on the other hand, it were intended to keep the velocity up to the normal value, four times the quantity of water would have to be pumped, which, as the static head would be 20 ft. or more, was a serious matter. The abolition of eddies might reduce corrosion, but it would at the same time seriously lower the efficiency of the condenser. The proposal to remove oxychloride deposits by means of acid (he presumed acetic acid would be used) had been dealt with by Mr. Philip, and would certainly require exceedingly careful control. As to the suggested cause of corrosion, to be satisfactory this must account for the concentration of the corrosion in the bottom of the water surface of the tubes; 90 to 95 per cent of the failures occurred here, there being often very great pitting at the bottom, while the tops and sides of the tubes were not very much affected. This could not be explained by any theory which attributed corrosion to local differences in the physical condition of the tube. Whether it might be due to the action of oxychlorides was more debatable, if the oxychlorides fell to the bottom of the tube; but if they stuck all round the tube, their action would not account for the excessive corrosion at the bottom which was always observed. The speaker believed that the entrance of cathodic particles into the tube was the main responsible cause, and that protection would be best secured by providing a counter electromotive force from an outside source.

At the opening of the evening sitting, Mr. Rolfe exhibited a condenser tube which showed very severe pitting on the steam side. This tube proceeded from the condensers of a land power station in which hundreds of tubes per year failed in the same way. The feed was peaty water, very soft, and the circulating water was sea-water. It was a remarkable fact that the pitting started and continued on the steam side and not on the water side. This was very interesting, since extreme corrosion took place generally on the water side. He (the speaker) thought there was more CO_2 in peaty water than in ordinary water, and Section V of the report, which dealt with corrosion in solutions other than sea-water, pointed out that a large amount of CO_2 in the water formed a very virulent solution. Peaty water, therefore, containing free CO_2 should not be used as it was, but lime should be added to it to get rid of the CO_2.

In the reply to the discussion, Mr. W. E. Gibbs said in their report the authors had stated that when fresh sea-water was tested with phenolphthalein it showed no trace of alkalinity, while if it were allowed to stand one night, the surface water became faintly alkaline; the speaker added to this statement that the less salt there was dissolved in the water the greater was the proportion of free CO_2. This point, he thought, might bear upon the results obtained in sea-water. The report had described the aeration very fully. This was of two sorts, a gentle and a violent aeration. In the gentle aeration, the motion of the water relatively to the surface of the metal was as small as possible, while in the violent sort the air current flowed through a large orifice and impinged directly upon the metal. The violent aeration was more effective in the production of zinc oxychloride on the surface of the metal than the gentle sort.

He was very glad to hear Mr. Smith emphasize certain sections of the report, and he (the speaker) felt strongly that the best course to pursue was first to deal with pure metals, and then to deal with more complicated alloys, while in regard to corrosion he felt that it would be necessary to define it in the future more accurately than had been done in the past. He hoped Mr. Smith would put before the Institute the details of his own researches. In reply to Professor Carpenter, the corrosion committee had not examined other copper-aluminium alloys. The chief trouble met with was local pitting, and they had taken phosphor-bronze as best resisting this. But no one alloy had been found to satisfy all conditions; one given alloy resisted one effect, and another alloy resisted another. Dr. Rosenhain had referred to the bulk of the report; he (the speaker) would have liked to have been able to reduce it, but it was difficult sometimes to see a work in the true perspective when standing too near it.

There was a large future for experiments with copper-aluminium alloys containing deoxydizing additions, such, for example, as vanadium. He (the speaker) had had an instance put before him of such an alloy containing 2 per cent of vanadium which stood remarkably well. The local corrosion of propeller blades was most interesting, and it had, no doubt, been due to the presence of local air-pockets. In condenser tubes on board ship the circulating water came in from the bottom, and under certain pressure conditions air was liberated to some extent, and there occurred a churning action, liberating air, apart from any effect due to the rise in temperature. The statement to the effect that it was necessary to bring the whole of the circulating water in contact with the hot condenser tube was most interesting. The zinc used in the corrosion committee's experiments was pure Brunner-Mund zinc, cast and cleaned. Mr. Rolfe's reference to corrosion occurring on the steam side of condenser tubes was also most interesting; the occurrence was, however, not new. The researches the committee had carried out had been essentially physicochemical researches, and he believed that without sound physicochemical work the problem of corrosion could not be solved.

Two Scholarships in Chemical Engineering

The Chemists' Club of New York announces the establishment of two scholarship funds, the income from which (approximately $500 per year in one case and $400 per year in the other case) is to be devoted to assisting financially deserving young men to obtain education in the field of industrial chemistry or chemical engineering. Its benefits will be open to properly qualified applicants without restriction as to residence, and may be effective at any institution in the United States which may be designated or approved by The Chemists' Club. Applicants must have completed a satisfactory high-school training, but preference will be given to young men who have supplemented this with additional academic work, especially in subjects which will form a suitable ground work for the more advanced study of applied chemistry and chemical engineering. All inquiries should be addressed to the Bloede Scholarship Committee or the Hoffmann Scholarship Committee of The Chemists' Club, 50 East Forty-first Street, New York City. Applications for the academic year 1916-17 should be in the hands of the committees on or before June 1, 1916.

Dr. Victor G. Bloede, the founder of the Bloede scholarship, is president of the Victor G. Bloede Company of Baltimore, Md.

Mr. William F. Hoffmann, the founder of the Hoffmann scholarship, is president of the American Oil and Supply Company of Newark, N. J.

Flotation and Cyanidation

A Symposium on the Cyanidation of Flotation Products and the Influence of Flotation on the Relative Importance of Cyanidation as a Metallurgical Process

With the extension of the flotation process to the concentration of gold and silver-bearing ores, new problems have confronted the metallurgist on the cyanidation of flotation products. The early use of flotation was confined mainly to the treatment of base-metal ores—copper, lead or zinc—in which the precious metals existed not at all or had a minor value. Now, however we find flotation displacing gravity concentration on sulphide gold and silver ores. In the treatment of some of these ores it has been customary to cyanide table concentrates, and in others, the tailings. The advent of flotation immediately raised the question of the feasibility of cyaniding these products, should they be produced by flotation instead of by conventional gravity processes. Certain difficulties seemed inherent, even before experiments were made, chief of which was the possible influence of the oil in the concentrate or tailing. Subsequent investigations confirmed some of the early ideas; and while progress has since been made, it is still evident that a large problem remains to be solved. Then, too, there was the question of the economic effect of flotation on the future use of the cyanide process; whether the position of cyanidation as the premier method of recovering gold and silver would be materially affected by the wider adoption of flotation.

We have deemed these phases of flotation to be of great importance, and have made an effort, through the medium of a questionaire, to elicit such information as is now available. A number of the answers are presented herewith, being offered for mutual profit by engineers more or less actively engaged in the treatment of ore by the two processes. While they sound no note of finality, they are distinctly encouraging in their general tone, and indicate that success can be achieved. Following are the questions and some of the replies received thus far. We invite further discussion of the subject.

1. Are oil-flotation products—concentrates and tailings—as readily cyanided as similar products from ordinary wet concentration?
2. To what are the difficulties, if any, to be ascribed, and what are the remedies?
3. Are the difficulties likely to prove serious enough to react against cyanidation and restrict its use?
4. Is it possible that a combination of flotation plus smelting may in some cases prove more economical than cyanidation?
5. Does flotation appear to-day in any sense a competitor of cyanidation in the treatment of gold and silver ores, or will it prove a valuable accessory process?

J. M. Callow.—In a general way, I would say that as far as flotation replacing cyanidation is concerned, it looks as if we could successfully do it in two places at least, namely, at Cobalt, Ontario, and also at Goldfield, Nev. In Cobalt I am making a ½-oz. tailing on a 9-oz. silver feed, and a 250 to 300-oz. concentrate. There are a great many difficulties in cyaniding these concentrates. They do not seem to yield to cyanide in any way. Mr. Jones of the Buffalo Mines Company is conducting a number of experiments to see how best to reduce them, including treatment by chlorine gas and chloridizing roast, but with what success we do not know.

As to Goldfield, we have been operating there with a 75-ton plant for the last sixty days, and are obtaining uniform results of better than 90 per cent of the gold, 75 per cent of the silver and all of the copper. The Goldfield people are treating these concentrates by cyanidation without any trouble after having given them a preliminary roast and an acid leach to remove the copper.

In some cases, where the smelting and freight facilities are good, I think flotation will entirely replace cyanide. In other places cyanide will be a supplemental process for the purpose of treating the concentrates from flotation. On other ores, higher cyanide recoveries can be made by using flotation to remove the interfering sulphides. This we did at the El Rayo Mine in Mexico. We found that we not only increased the recovery but reduced the cyanide consumption by giving the ore a preliminary flotation treatment. The oils used in the process evidently did not interfere with cyanidation.

Salt Lake City, Utah.

James Johnston.—You have presented an interesting lot of questions, the reply to which, from the point of view of our Cobalt ore, involves a great amount of work.

We are endeavoring to answer these same questions for our own account and without any guess work. We have installed as a unit to our low-grade mill a Callow plant of three roughers and one cleaner, and we are investigating the matter thoroughly.

In the meantime, until we finish our task, I cannot go on record as to how flotation may affect our metallurgy in this district.

Cobalt, Ont.

R. W. French.—1. We have not many data on this subject at this time, but do not anticipate any trouble in treating our flotation concentrates. The present indications are that we will not have to give flotation tailings any cyanide treatment, although this does not offer any unusual difficulty.

2. Possibly finer grinding of concentrates may be necessary, and other difficulties might develop according to the kind and quantity of oils used on the ore.

3. No.

4. Possibly in a few cases, depending on supplies and fuel, but generally not.

5. Regard flotation as an accessory process and not a competitor of cyanidation in the treatment of gold and silver ores.

Goldfield, Nev.

Philip Argall.—I must frankly state that I have had but little experience in the treatment of flotation concentrate by cyanide, as my work during the past four years has been almost entirely in the flotation of zinc sulphides.

1. Experiments made on Cripple Creek ore in 1907 showed that the float was very difficult to cyanide unless roasted, but after roasting no difficulty whatever was experienced.

2. The difficulties in that case and with some other ores tested in the laboratory were due to the oil. This condition was most easily remedied by roasting, provided very little silver was present; but roasting silver ore is fatal to good extraction by cyanidation.

4. It is my opinion that smelting the float concentrate, where gold and silver are present, is the better

method of procedure, but here again freight cuts an important figure. If a flotation plant is situated in a remote district, freight might eat up all the profits.

5. Flotation, like every new thing, is greatly overdone. At present the tendency is toward displacing cyanidation by flotation, but on the whole I do not look upon flotation as the competitor of cyanidation in the treatment of straight gold ores or medium-grade gold and silver ores, but of course every case must be studied separately.

Flotation will undoubtedly prove a valuable accessory in many cyanide plants.

Denver, Col.

Edwin Letts Oliver.—1. Flotation products ("oil" should not be used, to be strictly up to date in your terminology) are of such radically different natures that a general reply is not possible. Concentrates from silver ores are very difficult to cyanide, whereas concentrates from gold ores are frequently just as amenable to treatment as table concentrates. Flotation tailings are frequently more amenable to cyanidation than either unconcentrated tailings or tailngs from tables, and I believe that flotation will be extensively adopted as a preliminary step in many cyanide plants.

2. I have never found any two authorities to agree why flotation concentrates from some ores cannot be cyanided, whereas table concentrates from the same ore can be.

3. Difficulties have proven so serious in many cases that flotation could not be adopted, although it made a splendid recovery. In cases where the plant is far removed from a smelter and where transportation is difficult, it may be more economical to cyanide the concentrate, i.e., table concentrate, even though a lower recovery be made, than to ship the flotation concentrate.

4. It is very possible that a combination of flotation plus smelting will prove more economical than cyanidation. Transportation of the concentrate in many cases will be the deciding factor. On gold ores, a combination of amalgamation and flotation may in many cases supplant cyaniding. The Chichagoff Co. of Alaska has recently installed a flotation plant to follow their amalgamation plant. They recover 80 percent in free gold on the plates, but have never been able to make satisfactory recovery by table concentration, whereas flotation recovers better than 90 per cent of the value in the amalgamation tailing. This combination in mill treatment, we believe, has been but little discussed. I look forward to seeing plants of this kind in California, especially on the slate ores of the Mother Lode belt, where table concentration gives poor results and where table concentrate cannot be cyanided, and also where the slime tailing cannot be cyanided.

5. As yet, flotation has not been a serious competitor of cyanidation in the treatment of gold and silver ores, but it is already a valuable accessory, and we believe in time may eliminate 50 per cent of cyanide plants.

San Francisco, Cal.

Walter Neal.—I pass over Questions 1, 2 and 3 as I do not know the answer. For No. 4, I would say that on the result of tests made by myself at the Bureau of Mines Experimental Station in Salt Lake City last winter, we propose to put in a flotation plant at the El Favor mine as soon as Mexico is safe to operate in. I am sure that we can make a profit by floating and shipping the concentrate to the smelter. The main reason is that we can get no guarantee of a supply of cyanide. The price is high; but we might stand that if we were assured of getting it when we need it, but we do not feel like starting the plant again on a cyanide basis at present. Consequently, we shall float and ship, and when the cyanide and zinc supply again becomes normal we shall decide on the merits of the case whether to continue flotation or go back to cyanidation.

For No. 5, under present conditions, flotation is most decidedly a competitor of cyanidation as above, and I believe that for some ores it will compete under normal conditions.

I believe that a combination process will be worked out, but so far as I know this is not being practised anywhere as yet. There are difficulties in the way, but flotation is a husky youngster, and it is hard to say just where its growth will stop.

Hall, Mont.

Henry E. Wood.—1. No, they are not.

2. (*a*) Unless the oil-enveloped particles are freed from oil they cannot be so readily influenced by cyanide solutions. To remove the oil requires a temperature that is likely to roast the minerals more or less. At any rate it adds to the expense.

(*b*) Flotation is likely to throw into the concentrates fine particles of copper and other minerals (such as gray copper), which if present in small proportions are generally lost in wet concentration. If saved by flotation, they cause an excess of cyanide consumption. In attempting to cyanide a certain silver ore from Montana we found that a 48 per cent extraction consumed 72 lb. of cyanide per ton, which was prohibitive. Flotation of this ore saved 98 per cent in a 4000-oz. product.

3. I think flotation opens a field for the concentration of ores not susceptible to cyanidation. I do not think flotation will restrict cyanidation. It is quite evident that the proportion of ores subject to flotation will in time yield a recovery greatly exceeding that from cyanidation, because of the greater volume of ores that are not adaptable to the latter method.

4. The combination of flotation plus smelting is not likely to compete with cyanidation. The smelting of flotation concentrates is the most serious problem before the smelter to-day on account of dust losses, etc. It will probably result in a decided advance of smelting costs for such products.

5. Naturally flotation becomes a competitor of cyanidation in some cases, but not to an alarming extent. Of course, it is a valuable accessory process, but to take care of the flotation product calls for radical changes in smelting. In due time new smelting systems will, as the result of experience, be able to solve this most important problem. It is a very serious question with the smelter now, and sooner or later that issue will be raised. It is quite likely that new lixiviation methods will enable the smelting of such products to be dispensed with.

Denver, Col.

Charles W. Merrill.—1. No.

2. Not as yet prepared to say.

3. In my judgment, no.

4. Yes, it is possible in special cases.

5. In my opinion, flotation will prove a valuable accessory process to cyaniding within the next few years.

San Francisco, Cal.

Bernard MacDonald.—1. No.

2. The difficulties are due to (*a*) the oil films that adhere tenaciously to the metal-bearing sulphides in the concentrates. These oil films constitute a protective covering which prevent the cyanide solution from coming freely into direct contact with the sul-

phide particles, a condition necessary for effectively dissolving out the gold and silver contained in them; and (*b*) the carbon contained in the oil films is in position to be immediately available to react as a precipitant on the gold and silver that may be dissolved out of the sulphides and brought into the cyanide solution. When thus precipitated, the gold and silver becomes insoluble in further contact with the cyanide solution. The commercial result is, therefore, the same as if the gold and silver had never been dissolved out of the concentrates. As a remedy for obviating these results, I suggest submitting oil flotation concentrates to a dead roast, which would drive off the carbon contained in the oil films and leave behind only an insignificant amount of ash, which would not affect unfavorably the subsequent cyanidation. The roasted concentrates would be in a porous condition, so they could be effectively and cheaply cyanided by percolation.

3. There are good and sufficient reasons for the conclusion that oil-flotation will give better commercial results than cyanidation on certain silver sulphide ores that contain small percentages of copper, manganese and antimony. In many cases such ores are now treated profitably by cyanidation, notwithstanding the comparatively low percentage extraction and the high consumption of cyanide and other chemicals used in the process. But the recent advance in the price of cyanide, zinc and other reagents used in the cyanide process will make the oil-flotation treatment a desirable alternative for these ores. It is perhaps going too far with present knowledge to say that even the single sulphide silver ore (argentite) that is now considered the most docile for cyanide treatment will eventually be preferably treated by oil-flotation, but that is possible if not probable.

However, for silicious gold and silver ores wherein the silver occurs in the haloid combinations such as the chlorides and bromides, the cyanide treatment will remain the standard method.

4. Yes. In cases where the silver occurs in more or less refractory combinations as above mentioned, and especially where it occurs associated or combined with galena, flotation plus smelting will be more economical than cyanidation, but these cases will be affected by transportation facilities.

5. Covering the answer to this question, and as a general conclusion from the answers to the previous questions, the writer's opinion is that oil-flotation will have to be reckoned with as a strong competitor of cyanidation within the limitation outlined above.

As an accessory process to cyanidation, flotation will doubtless also have a field.

Los Angeles, Cal.

Thomas B. Crowe.—1. Yes.

2. To oil coating on mineral, the remedy for which is roasting.

3. Yes, unless the oil is burned off.

4. Yes.

5. Yes, so far it has not been made an accessory process.

Victor, Col.

Charles A. Chase.—1. I have not myself tried to cyanide oil-flotation concentrates or residues, but authoritative articles in the technical press indicate that the cyanidation of these materials is unsatisfactory to date.

2. I have always assumed that the flotation reagents would be destructive of cyanide and prejudicial to good extraction.

3. I think so.

4. I think it probable.

5. It is a competitor.

I do not see any object in speaking of flotation as a competitive process. What it really does is to make metallurgy more flexible by providing a new tool. For years the practice of cyanidation has been expanded to more and more difficult ores, ores which are now found readily amenable to the simpler process. This is particularly true of the silver ores. In my own practice I found silver ores in Ouray County, Col., that could be cyanided profitably following table concentration, but flotation is far better adapted. It seems to be a case for careful study to adapt processes to the individual ore.

Denver, Col.

Charles E. Locke.—1. From personal experience we cannot say whether oil-flotation products are as readily cyanided as wet concentration products.

2. The differences, if any, can only be ascribed to the reagents used, namely, the oil and the electrolyte. Where the electrolyte is of acid character, one would naturally expect that more lime would have to be added to overcome the acidity, but it does not seem that the conditions would be any different from those which existed where concentration is carried on in acid water. The remedy, provided a remedy is found to be necessary, would apparently be complete drying, to the point of incipient roasting. As to the effect of oil in cyaniding, I do not feel that I am sufficiently versed in the chemistry of cyaniding to predict what would happen; but we all know that a reducing agent in the cyanide solution is considered to be harmful, in that it causes reprecipitation of the gold. All oils come within the class of reducing agents, and would presumably cause this effect. The remedy would appear to be the same as that for electrolyte, namely, drying.

In this connection I recall that only recently a friend of mine told me of his experience with flotation zinc concentrates. He treats these concentrates electrolytically. At first he only dried them before the electrolytic treatment, but he found that the small quantity of oil which they contained was very harmful, and he has therefore been obliged to continue the drying to the point of redness, and thus entirely burn off, or, as he expressed it "fry out the oil."

3 and 4. The answers to these questions will be given by the ledger. Where the margin of profit is small, there will certainly be instances where the extra cost of preparing the flotation concentrates for cyaniding will tend to restrict its use. Further, if a mill is favorably located regarding freight and smelting rates, there would appear to be a possibility that flotation plus smelting might be more economical than cyaniding.

5. The development of flotation is so rapid that one is kept busy every minute in keeping up with progress. It is eight months now since I traveled through the West; at that time I did not find flotation considered as a competitor of cyaniding, except that certain men, especially Mr. Charles Butters, were predicting that it would become a competitor. No instances have come to my attention as yet where flotation has come into competition with cyaniding, but there seems no reason to say that this condition will continue for all future time.

We can surely say that flotation is going to be a valuable adjunct to cyaniding. The Nipissing Mining Company, at Cobalt, reports that they are installing a working unit in their mill to treat the tailings from cyaniding, their laboratory experiments having indicated that an additional recovery may be

made by flotation on these tailings at a profit. The great advantage of cyaniding always has been that it delivers a product in the form of bullion, that is, in a very concentrated form which could be sold in the open market, and required no further treatment except, possibly, parting. The fact that flotation yields, as a rule, sulphide concentrates, which are more bulky than metal, and which require further treatment before they become marketable, is going to be a considerable handicap.

Boston, Mass.

Flotation Symposium

Joint Meeting of New York Sections of American Institute of Mining Engineers and American Electrochemical Society

A very enjoyable joint meeting, preceded by an informal dinner, was held on Friday, May 12, at The Chemists' Club, New York City, by the New York Sections of the American Institute of Mining Engineers and of the American Electrochemical Society. Both sections elected officers for the coming year, as follows:

New York Section American Insitute of Mining Engineers—David H. Browne, chairman; Percy E. Barbour, vice-chairman; A. D. Beers, secretary; C. A. Bohn, treasurer.

New York Section American Electrochemical Society—Dr. Colin G. Fink, chairman; John V. N. Dorr, vice-chairman; J. Malcolm Muir, secretary-treasurer.

The subject of the evening was a symposium on the "how" and "why" of flotation. The two principal speakers were Mr. **George D. Van Arsdale,** consulting chemist of Phelps, Dodge & Co., who discussed the "how" of flotation, and Prof. **Wilder D. Bancroft** of Cornell University, who discussed the "why."

Mr. Van Arsdale defined flotation as that process of concentration which utilizes the different behavior of different kinds of particles toward the surfaces of liquids and gases and separates them, irrespective of the action of gravity. Since we have, therefore, to deal in flotation with surface phenomena, the subject is closely connected with colloids.

By means of a series of very interesting experiments shown on the screen with a projection lantern, Mr. Van Arsdale discussed, step by step, the different items which influence and determine flotation. Under what conditions will a cylindrical metallic wire float horizontally on water? Gravity acts on the wire trying to sink it, and this force is the greater the greater the specific gravity and the diameter of the wire. Experiment shows that there is a maximum diameter, for which a wire of a certain material will float, and that this maximum diameter can be calculated very closely from surface-tension formulæ. This proves absolutely that surface-tension is at the bottom of the force which acts against the action of gravity and makes the wire float. What factors determine this force? First, the shape of the particle and, second, the surface angle, and the surface angle again depends on the surface film on the particle. This surface film may be either a solid (copper oxide behaves very differently from copper sulphide) or a liquid (oil) or a gas or an electrostatic charge (capillary electrometer) or a combination of these. With respect to the action of gas films it was conclusively shown by experiment that the method of producing the gas is without influence on the flotation.

On the basis of his classification Mr. Van Arsdale discussed the principal phenomena of flotation, and finally took up the discussion of flotation oils. They have a double function as oilers (furnishing a nonwet film on the particle) and as foamers (furnishing a froth by reducing the surface tension).

The interesting suggestion was made by Mr. Van Arsdale not to add the oil as a whole as is done at present, but according to the two different functions to be fulfilled, to add first the oiler to the mill (to coat the particles) and afterwards the foamer to the flotation machine. He also suggested that petroleum may be used as oiler.

Emulsifications are detrimental to flotation. Hence any agent which tends to emulsify the oil (like tannin, saponin, glue) is detrimental to flotation, while reversely anything that counteracts emulsification (like sulphuric acid) helps flotation.

Mr. Van Arsdale concluded that we are only beginning to realize the scope of the flotation process, we may even have flotation without oil.

Mr. Van Arsdale's flotation experiments in a little glass cell thrown on the screen by means of a projection lantern were exceedingly well chosen to illustrate typical cases and succeeded very well.

Prof. Wilder D. Bancroft spoke in his characteristic felicitous and witty manner. He emphasized that in principle he was in full accord with Mr. Van Arsdale, and differed from him only in the way of looking at the problem and describing it in words. Instead of using the contact angle as the fundamental element, he uses the degree of wetting as basis. Water wets glass readily; mercury does not wet glass readily; water does not wet greasy glass. On such simple facts of experience we can base a description of flotation phenomena, and then the matter becomes really simple. We have selective wetting; alcohol will displace water on metal, etc.

If we have oil, water and a solid, we have three cases: the solid is entirely wetted by water, or it is entirely wetted by oil, or it is simultaneously wetted by oil and water. In flotation of a sulphide ore with a silicic gangue, the latter stays entirely in the water phase, while the sulphide goes into the "interphase" or into the oil. But this flotation process is not a special phenomenon depending on oil, as an exactly analogous distribution between the different phases can be obtained with a great many chemical materials.

Professor Bancroft explained why alkaline solutions are less satisfactory for flotation (adsorption of hydroxyl) and acid improves flotation. Flotation differs at different temperatures, because selective wetting depends on the temperature. What is wanted in flotation is an oil froth, not a water froth. Soap, etc., produces water froth, and is detrimental. No pure oil is a foamer; a foamer always requires colloidal matter or suspensions. This suggests the possibility of the synthesis of foamers.

When very little oil is used it is possible that in addition to oil-water flotation the air may come in, and this may be an important matter; this is open to experimental investigation.

Prof. R. H. Richards of the Massachusetts Institute of Technology, who presided during the technical session, opened the discussion with a reference to the Anaconda Copper Company, which had installed $300,000 worth of round tables which produced a very important saving, but were thrown out when flotation came in. He also told of another case in which flotation saved all the fine stuff and Wilfley tables the coarse matter.

After some further discussion in which Messrs. Free, Reed, Baskerville, Megraw and Bancroft participated, the meeting was closed by Dr. C. G. Fink, chairman of the New York Section of the American Electrochemical Society. The attendance was not far below 300.

Cost-Accounting in the Construction and Operation of a Copper Smelter

Construction Accounts for a Copper Smelter

BY ERNEST EDGAR THUM, E.M.*

The following list of accounts is believed to be adequate to cover practically all the usual construction for a copper smelter. Accounts for concentrator and refinery have been omitted, but it is patent how the list could be extended to cover such additional departments.

GENERAL CONSTRUCTION EXPENSE, ACCOUNTS C 0 TO C 9

Camp and Commissary	C 0
Railroad Spurs	C 1
Wagon Roads	C 2
Electric Lines	C 3
Pipe Lines	C 4
General Clean Up	C 5
Watchmen	C 6
Central Concrete Mixing Plant	C 7
Construction Machinery	C 8
Misc. Small Tools and Equipment	C 9

STORAGE-BINS CONSTRUCTION ACCOUNTS; ACCOUNTS C 10 TO C 19

Ore Bedding Plant	C 10
Thawing Shed	C 11
Sampling Mill Bins	C 12
Blast Furnace Bins	C 13
Roaster Bins	C 14
Reverberatory Bins	C 15
Converter Bins	C 16
Flue Dust Bins	C 17
Boiler House Bins	C 18
———	C 19

SAMPLING-MILL CONSTRUCTION ACCOUNTS; ACCOUNTS C 20 TO C 29

Building	C 20
Crushing Machinery	C 21
Screens	C 22
Samplers	C 23
Spouting	C 24
Elevators	C 25
Conveyors	C 26
General Power Transmission	C 27
Bucking Room	C 28
Misc. Small Tools and Equipment	C 29

BLAST-FURNACE PLANT CONSTRUCTION ACCOUNTS; ACCOUNTS C 30 TO C 39

Building	C 30
Furnaces	C 31
Flue Connections	C 32
Dust Chamber	C 33
Water Tank	C 34
Elevators	C 35
Launders and Sluices	C 36
———	C 37
———	C 38
Misc. Small Tools and Equipment	C 39

ROASTING-PLANT CONSTRUCTION ACCOUNTS; ACCOUNTS C 40 TO C 49

Building	C 40
Furnaces	C 41
Flue Connections	C 42
Dust Chamber	C 43
Water Tank	C 44
Elevators	C 45
Conveyors	C 46
General Power Transmission	C 47
———	C 48
Misc. Small Tools and Equipment	C 49

REVERBERATORY-PLANT CONSTRUCTION ACCOUNTS; ACCOUNTS C 50 TO C 59

Building	C 50
Furnaces	C 51
Flue Connections	C 52
Dust Chamber	C 53
Waste Heat Boilers	C 54
Fuel Plant	C 55
Launders and Sluices	C 56
———	C 57
———	C 58
Misc. Small Tools and Equipment	C 59

CONVERTER-PLANT CONSTRUCTION ACCOUNTS; ACCOUNTS C 60 TO C 69

Building	C 60
Converters	C 61
Flue Connections and Hoods	C 62
Dust Chamber	C 63
Cranes	C 64
Slag Casting Machine	C 65
Copper Refining Furnace	C 66
Copper Casting Machine	C 67
———	C 68
Misc. Small Tools and Equipment	C 69

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MAIN FLUE AND STACK CONSTRUCTION ACCOUNTS; ACCOUNTS C 70 TO C 79

Fume Plant Building	C 70
Fume Plant Equipment	C 71
Connecting Flues	C 72
General Dust Chamber	C 73
Main Stack	C 74
———	C 75
———	C 76
———	C 77
———	C 78
Misc. Small Tools and Equipment	C 79

BOILER-HOUSE CONSTRUCTION ACCOUNTS; ACCOUNTS C 80 TO C 89

Building	C 80
Boilers	C 81
Flue	C 82
Smoke Stack	C 83
Live Steam System	C 84
Coal-Handling System	C 85
Ash-Handling System	C 86
Condensing System	C 87
Feed Pumps	C 88
Misc. Small Tools and Equipment	C 89

POWER-HOUSE CONSTRUCTION ACCOUNTS; ACCOUNTS C 90 TO C 99

Building	C 90
Water Supply Pumps	C 91
High-Pressure Pumps	C 92
Blast-Furnace Blowers	C 93
Converter Blowing-Engines	C 94
90-Lb. Air Compressors	C 95
Direct-Current Generators	C 96
Alternating-Current Generators	C 97
Substation and Switchboard	C 98
Misc. Small Tools and Equipment	C 99

TRANSMISSION-LINE CONSTRUCTION ACCOUNTS; ACCOUNTS C 100 TO C 109

General Water Supply Tanks	C 100
Water Supply Lines	C 101
High-Pressure Mains	C 102
Blast-Furnace Air Main	C 103
Converter Air Main	C 104
90-Lb. Air Lines	C 105
Electric Power Lines	C 106
Electric Lighting Lines	C 107
Steam Power Lines	C 108
Steam Heating Lines	C 109

YARDS AND RAILROAD TRACKS CONSTRUCTION ACCOUNTS; ACCOUNTS C 110 TO C 119

Interconnecting System	C 110
Storage Bins Trackage	C 111
Slag Tracks	C 112
Blast-Furnace Charge Tracks	C 113
Roaster Charge Tracks	C 114
Reverberatory Charge Tracks	C 115
Converter Charge Tracks	C 116
Flue-Dust Tracks	C 117
Copper Tracks	C 118
Misc. Small Tools and Equipment	C 119

SHOPS CONSTRUCTION ACCOUNTS; ACCOUNTS C 120 TO C 129

Machine Shop	C 120
Smelter Mechanics Shop	C 121
Boiler Shop	C 122
Blacksmith Shop	C 123
Carpenter Shop	C 124
Pipe Shop	C 125
Electric Shop	C 126
Bricklayers and Mason Shop	C 127
Locomotive and Car-Repair Shop	C 128
Crane-Repair Shop	C 129

MINOR BUILDINGS CONSTRUCTION ACCOUNTS; ACCOUNTS C 130 TO C 139

Office Building	C 130
Laboratory	C 131
Change House	C 132
Warehouse	C 133
Oil House	C 134
Powder House	C 135
Lime House	C 136
Outside Toilets	C 137
Watchmen Shanties	C 138
Scale Houses	C 139

MISCELLANEOUS CONSTRUCTION ACCOUNTS; ACCOUNTS C 140 TO C 149

General Yard Grading	C 140
General Yard Lighting	C 141
Main Sewer	C 142
Fences	C 143
Fire Department Equipment	C 144
Water Development	C 145
Telephone System	C 146
Weather Bureau	C 147
———	C 148
———	C 149

The system underlying this arrangement is obvious; briefly to group together the different accounts necessary for a department or similar class of structures, each account number possessing the same digit in the tens place. Thus all accounts in the sixties refer to converter plant. The unit digits have been arranged as far as possible to have a similar significance; e.g., 3 for "dust chamber," 9 for "operating tools." Account 69, therefore, will represent operating tools for the con-

verter department, 119 the same for yards and railroad tracks.

Furthermore, all accounts for buildings (having 0 for their unit digit) can be subdivided in exactly the same manner; in this way, $C\frac{20}{6}$, $C\frac{30}{6}$, $C\frac{40}{6}$, etc., will all represent, say, wiring and lighting for the building whose account is C 20, C 30 or C 40.

A quite full list of accounts covering a large departmental building is given below, and will be adequate for all mill-building construction without material change.

1. Excavation and Backfilling.
2. Foundation.
3. Floors and Paving.
4. Steelwork and Erection.
5. Brickwork.
6. Wiring and Lighting.
7. Steam Piping.
8. Water Piping.
9. Air Piping.
10. Sewer Connections.
11. Ventilators.

17. Siding and Partitions.
18. Doors.
19. Windows.
20. Roofing.
21. Walks and Stairways.
22. Sprinkler System.
23. Departmental Office and Furniture.
24. Tool Room (excluding tools).
25. Toilets.

Quite a number of these sub-accounts need not appear in the minor buildings. In such case it is desirable merely to leave them blank without disturbing the prearranged list, so that sub-number 22, for instance, shall always represent sprinkler system. Shop accounts C 120 to C 129 will obviously require slight extensions to cover cost and installation of machine tools and motive power. Close adherence to this scheme will insure a practically self-indexing system, capable of indefinite expansion.

In a similar manner, accounts for furnace construction can be subdivided as follows:

1. Excavation and Backfilling.
2. Foundation.
3. Platforms.
4. Steelwork and Erection.
5. Brickwork.
6. Electrical Equipment.
7. Steam Piping.
8. Water Piping.
9. Air Piping.
10. Sewer Connections.
11. Hoods and Shields.
12. Feed-Bins and Gates.
13. Jib Cranes.

Observe that the sub-numbers from 1 to 11 have the same significance (in most cases the same wording) as the building sub-numbers, while numbers 12 and 13 are accounts peculiar to furnace construction. This list can evidently apply almost without change to all classes of machinery.

Accounts C 110 to C 119 require separate treatment. A list of sub-numbers for track construction, following that of the Interstate Commerce Commission, is as follows:

T 4. Grading.
T 5. Ballast.
T 6. Ties.
T 7. Rails, Track Fastenings and Other Track Material.
T 8. Frogs, Switches and Special Work.
T 9. Rail Bonding and Insulating Joints.
T 10. Retaining Walls.
T 11. Track Laying and Surfacing.
T 14. Trestles.
T 15. Culverts.
T 16. Grade Crossings, Fences, Cattle Guards, Signs.
T 17. Interlocking and Signal Apparatus.
T 19. Poles and Fixtures.
T 20. Underground Conduits.
T 21. Trolley Wires.
T 22. Third Rail.
T 28. Track Scales.
T 35. Cars.
T 36. Locomotives.
T 39. Miscellaneous Equipment.

Since the correspondence between significance and numeral is lost in this subdivision, the sub-numbers are prefixed by the letter "T," in order to immediately arrest attention. Thus, in account $C\frac{113}{T6}$, the "T" will divert the mind from "wiring and lighting," its usual meaning, to the special meaning "ties" for the blast-furnace charge track.

Instructions for Employees

Each engineer, foreman and clerk who has to aid in the distribution of charges will need to refer constantly to a complete list of the construction accounts. For this reason it will be necessary to prepare a number of books for these men to carry about with them. A quantity of leaves for the standard loose-leaf notebooks should be printed listing the different general sub-numbers. The name and number of the account can be typed at the top of the leaf, any superfluous sub-numbers ruled out or extras inserted. The sheet is then dated, and inserted into a book which will contain the complete classification. Any additions or alterations to the list can easily be made by simply inserting corrected sheets in the appropriate places. Warehouse orders, shop job orders, teaming orders and a supply of blank memorandum sheets will complete the book.

The drawing room can render invaluable service toward insuring correct segregation of expense by placing on each drawing the proper account number covering the work drawn up, as far as possible confining the subject matter of one detail drawing to one sub-number. On general drawings the scope of each account appearing should be carefully differentiated; this drawing then is immediately useful as an index for that particular construction. In addition to this help, however, it will be desirable to preface the account book by brief general rules as to the scope and meaning of the various numbers. For instance, it should be pointed out that excavation for a building will include grading of the site, digging pits for building column piers, trenches for retaining-wall footings, finishing the grade for floors or tracks inside the building. Trenches for pipe lines, however, should be charged to the piping in question. Pipe accounts end at the building lines; outside this their construction is chargeable to "transmission lines," accounts C 100 to C 109. If a foreman needs a shovel for a laborer working at the converter tool room, he should charge it to "construction expense," account C 9, "small tools and equipment," and not to account $C\frac{60}{1}$, "excavating for converter building," nor to account $C\frac{60}{24}$, "converter tool room." A stock of shovels for converter operation will be charged to account C 69, "converter small tools."

Note, however, that a construction foreman would have no right to make a charge to this account, and there is little danger of such a charge going through, if the organization described is employed. If it is within the authority of a foreman to requisition the warehouse for small tools for the use of his gang, and he should make an erroneous charge for them, it would be noted and corrected by the timekeeper later in the day when he inspected the cards in the supply room. Each foreman's authority for making charges should be limited strictly to the few accounts upon which he is working. This will still the temptation to charge labor or material to another man's job in order that his own may appear with a low cost. But any charge which may slip through in error is practically certain to be caught before long by the timekeeper, who, devoting his whole

attention to this matter, will become quite expert in the proper segregation of charges.

We might expand at some length on the necessary qualifications for a good timekeeper to handle the duties outlined above. Suffice it to say that I have found that a reliable level-man is the best. He already knows the elements of construction and has the habit of accuracy permanently instilled. The rest is child's play. The extra salary he will require will be repaid many times over.

Comparison of Literal and Numeral Systems of Notation

Many of the modern authors on accounting favor a scheme which will denote the different accounts, not by numerals but by letters, using the initials of the wording wherever possible. Under such a scheme S would denote "shop," SM "machine shop." These mnemonic aids are rapidly exhausted, however, and we will find SMA meaning "excavation for the machine shop," SMB "foundation," and so on. It seems that 1 is as good a symbol for excavation as A; the added advantage is that the number series is not limited to twenty-six members. The system expounded here reserves letters for sub-accounts under operation, and numbers for sub-accounts under construction, thus affording an automatic segregation of these two important classes of charges.

The subdivision of main estimates as given may be regarded by the auditor as much too minute for the needs of the general accounts. On the other hand he may desire to get more detail in some accounts, such as those covering furnaces. Should different types of roasters be constructed, it would be necessary to distinguish between them in all their parts. This can easily be done by numbering the furnace batteries, and then denoting, say, "brick work in battery No. 2" by

account $C\frac{41}{5}$ No. 2.

Even the above fairly detailed distribution will be inadequate for the purposes of the cost-clerk. He therefore will consult with the chief engineer and determine what details will be most illuminative and useful, and will instruct the timekeepers and estimators how to collect the data in order that the desired segregation may be obtained. Under "steelwork and erection" the following list may be desired:

Sorting in the yard.
Hauling to the erection gangs.
Assembling bents on the ground to be erected complete.
Erecting steel by locomotive crane.
  by derrick car.
  by traveler.
  by gin poles.
  by derricks.
  by hand lines.
Constructing and maintaining traveler.
Moving traveler forward.
Moving gin poles.
Moving derricks.
Erecting these various types of tools.
Dismantling them.
Erecting false work.
Dismantling false work.
Riveting gang scaffolds.
Riveting.
Cutting out and redriving bad rivets.
Bolting floor plates.

Timekeepers and estimators in particular will be required to see that each charge made to $C\frac{50}{4}$ will bear a tersely worded description which definitely refers it to some item in this list. Doubtful cases should be referred to the cost-clerk for decision, who may extend the list to cover unexpected developments.

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The Grading Industries

BY EDWARD S. WIARD

(*Continued from page 533*)

Description of Industrial Operations Employing Grading

Abrasive Grains and Products

The term "abrasives" includes natural and artificial products. The principal natural abrasives are emery, corundum and various forms of silica and silicates. The artificial abrasives are carborundum, alundum, etc.

I will leave the preparation of abrasive papers and grits to the end of this section, dealing first with emery, which, in the popular mind, is the abrasive par excellence. Emery deposits occur in the whole length of the Appalachian range associated with metamorphosed and igneous rocks, principally schists, but the annual production is only about 1000 tons. The most famous deposits were at Chester, Mass. The color of emery is black or grayish-black, due to the intimate presence of hematite. The abrasive is consequently an intimate mixture of aluminium and iron oxides, the proportion of the latter varying in percentage.

Much oriental emery is graded in the United States, some of the old mills near Chester, idle on domestic ore, being employed for this purpose. There are also grading plants at Perth Amboy, N. J.; Easton, Pa., and North Grafton, Mass. All the emery graded in the United States comes from the Grecian Archipelago and Turkey. In 1914 some 13,000 tons was imported, having a value of $500,000. The emery comes over principally as ship ballast. The Grecian government practically has a monopoly of the emery exported from the Archipelago by taxing grades inferior to its own deposits at Naxos, where the emery occurs very pure and massive.

The methods of grading emery do not differ from those to be described later on under sandpaper and artificial abrasives. The useful property of emery as an abrasive, as with corundum, and particularly when made up into wheels, depends upon its ability to crumble under pressure, thus always presenting fresh cutting surfaces. Emery and corundum which is tough and grinds to rounded grains is worthless, particularly in wheels, where with use it will acquire a glassy surface. Owing to its lower price, emery is still able to maintain a hold in many fields, particularly in those employing abrasive cloth.

No corundum has been mined in the United States since 1906. Practically all this material comes from mines in the vicinity of Craigmont, Ontario. The corundum occurs in syenite, and in crystals up to 1½ in. in length. The percentage varies from 5 to 15. The ore is mined by open cuts, crushed with rolls and crushers, and cleaned by wet concentration methods, using jigs and tables. The principal difficulty is in getting rid of the feldspar, which has a gravity 2.5 to 2.8, that of corundum being 3.9 to 4.2. But one company controls the field at present, The Manufacturers Corundum Company. During 1912 it shipped 1900 tons of graded product valued at $239,000, and worth 6¾ cents per pound. Of late years the production has fallen off.

Quartz and Garnet

Quartz is used for sandpapers in the form of vein quartz and quartzite, but the latter is not so good for abrasive purposes as the former, for the grains are apt to be rounded when unlocked by crushing. Massive quartzite, however, does not offer this difficulty. The bulk of the quartz for abrasive purposes comes from

large pegmatitic quartz veins, and on this account the mining of the quartz often goes on with feldspar mining. So-called flint papers are merely trade names, for the expense of flint pebbles as an abrasive would be prohibitive. Flint would, however, make an excellent abrasive, for its fracture is deeply conchoidal and leaves a sharp, glassy cutting edge. The cheapest grade of imported flint pebbles costs as much as $8 per ton in the form of ground quartz. The unground quartz is worth as little as $1.65 per ton at the quarries.

The mining of abrasive garnet for sandpapers, owing primarily to the superior hardness of the material, is an industry which has been slowly increasing in production from year to year. In 1914 the production was 4000 tons. The mining of this material is confined to the States of New York, New Hampshire and North Carolina.

At one time garnet grains found application in the shoe industry, but its use has been supplanted by harder abrasives. For finishing hardwood, garnet paper does not break down and fill the wood like flint paper, and less time is lost in recovering the finishing rolls than with the latter.

The most valuable form of garnet is almandite, which has a superior hardness to the ordinary varieties, whose range is from 6.5 to 7.5. The garnet of this variety from the Adirondack region has a hardness from 7.5 to 8. It occurs in lenses of amphibolite in acidic granite, in crystals ranging in diameter from 1 in. to over a foot.

In working the rock it is broken down by ordinary quarry methods of picking or blasting. The garnet is recovered by hand-picking or by mechanical methods. When mechanical methods are employed the problem has been to separate the garnet from the hornblende, the latter having a specific gravity ranging from 2.9 to 3.4, while the garnet ranges from 3.15 to 4.3. In the Adirondack region, particularly at 13th Lake, Warren County, and Gore Mountain and Garnet Peak, there is usually a well-defined cleavage set up in the crystals, which are of a distorted dodecahedral form. The cleavage is usually parallel to one of the dodecahedral faces, and this gives a good surface for attachment to the paper as well as good cutting edges. The ordinary cleavage of garnet is subconchoidal. Garnet also occurs in New Hampshire, one notable locality being in Merrimac County. About 40 to 50 per cent of the rock is garnet, the associated minerals being quartz, feldspar and biotite. The garnet crystals are small and contain included quartz and biotite, necessitating fine crushing. The garnet is separated from the impurities by a Sutton, Steele & Steele dry table. In preparation for the tables the material is crushed and screened to four sizes, material finer than 0.36 mm. diameter being rejected. The coarsest grain treated does not exceed 2 mm. in diameter.

Artificial Abrasives

The first and greatest of the artificial abrasives is carborundum, or the carbide of silicon, details of the manufacture of which have appeared so often in the technical press that the brief description which would be possible here can be omitted. The same reflection would apply to a description of alundum, the artificial oxide of aluminium. Crushed steel is much used in the stone-finishing trades. In manufacture, high-grade crucible steel is heated nearly white hot and quenched in cold water. The fragments from the bath are then gathered up and crushed, yielding on grading particles varying from the finest powder to 6-mesh pieces. The material is crushed in stamps and a roughing grading is given by rotary screens and the finishing grading by flat screens. As in grading other abrasives silk cloth is used on the fine sizes in preference to metal cloth.

Following the grading operations, the various grades of particles are tempered: the 6 to 60-mesh size is heated to 450 deg. and quenched at a straw color, while diamond-crushed steel, 60 to 200-mesh, is heated to higher temperatures. The same firm manufacturing the steel products also prepares chilled cast-iron shot for similar uses. The products are recommended by the manufacturers for polishing, sawing and grinding of granite, marble, stone, onyx, brick, glass, etc. In ordinary stone-polishing and grinding operations, the desired size of abrasive, depending on whether a polishing or grinding effect is wanted, is fed through the center of the gyratory grinding wheels, and spreads itself between the grinding surface and the piece being finished. Wheels 12 to 13 ft. in diameter are used for stone; 6 to 7 ft. in diameter for brick; 30 in. for beveling glass.

Metal and Silk Screens Commonly Used

In grading the hard abrasives the almost universal method is by screening down to the neighborhood of 200-mesh sizes. Flat screens are preferred in most grading establishments, although in one in which I visited revolving screens were employed. Silk cloth is preferred below 30-mesh size, largely because it does not blind so easily, and also because it is cheaper. The first cost is cheaper on the square-foot basis, and the relative wear, while in favor of the metal screens, probably does not show much if any disparity on ordinary abrasives when the greater cheapness of the silk cloths is considered. In addition to blinding more readily than the silk cloth, the metal screen is more difficult to free on becoming blind.

In most of the grading establishments the flat screens are strung one beyond the other. The following description will serve for the operations by this arrangement. The abrasive material is crushed to the neighborhood of 14-mesh, then fed to a splitting box with two screens, the upper one of which is 14-mesh and the lower 54-mesh. The oversize of the 14-mesh screen goes to waste, as it contains too much foreign matter. The undersize of the 14-mesh screen drops onto the 54-mesh screen and makes over and under sizes. The oversize of the 54 goes to a battery of eight screens arranged one ahead of the other, the coarsest grade being taken off the first and successively finer off the lower ones. The undersize of the 54-mesh screens also goes to eight screens, making in the same way eight grades. The screens rest on flat irons at the side, have a slope less than 10 deg. and stroke of about an inch. The number of shakes per minute is approximately 200. Motion is given to the screens by ordinary jig eccentrics. The frames are wood and the space for the individual screen is about 18 by 40 in. For sizes above 30-mesh, wire cloth is used and silk below 30-mesh.

The various undersizes are conveyed to the screens next below those from which they originate along flat wooden bottoms parallel to the surface of the screen cloth. The striking feature of the grading in most abrasive factories lies in the very light loading; on the lower screens particularly one has to look closely to see any of the grains passing along. The oversize grains advance by bounds, and most certainly the work done is no better than would obtain with less speed or greater loading. The only advantage of this mode of operating that occurs to me is the possibly greater life of the screen cloth. There surely can be no screening effect while the particles are in the air on a bound forward. In the particular establishment under consideration the load on a single battery of screens cannot exceed 3 tons

per day of eight hours, and the load per square foot of screen surface does not exceed 2 tons per day of twenty-four hours.

At the Armour & Co. sandpaper factory a battery of shaking screens is used, one being superimposed above the other, the top screen terminating at a point farther along the discharge than the lower ones, with the terminals of the others successively less advanced. This arrangement is very compact and provides room for a series of parallel discharge spouts for the oversizes at the end of the machine. It has the possible disadvantage that some of the undersizes may reach the screen next below at a point near the discharge, and the wear on the screens may be greater than the arrangement which has been described in detail, owing to impact from the material falling from one screen to the other. The screens are inclined and are shaken, and also given a bump at each stroke, which provides a sharp differential and aids in clearing the apertures of lodged grains. The batteries are said to occupy a floor space of but 20 in. by 48 in., and the work of the machine, when fed at the proper rate, is said to repeat within 5 per cent and to be 98 per cent accurate as shown by hand-screen test.[1]

Where silk cloth is used on the screens it should not be subjected to sudden changes of temperature, otherwise it is apt to tear.

At most of the plants grading quartz for sandpaper some means must be provided for regulating the proportions of the different sizes, the demand for which varies from time to time. At one of the plants visited this was done by first crushing the rock to a size capable of being nipped by medium sizes of rolls. A battery of the latter were provided, set for different sizes, and the manufacturers were consequently able to route as much or little to any particular roll as they pleased, and thus control the output to meet any extraordinary demand for a particular size.

The medium grits in the form of sandpapers which are in greatest demand are those from 40 to 84-mesh. The sizes of sandpapers are shown in Table I. Screens are universally employed for preparing the gradings, and have the merit that unless there is a hole in them there will be a rigid limiting of the upper sizes, though there may be, and often are, grades smaller than the lower size. It is claimed that oversize grains are very harmful in any particular grading, and this is more in evidence as the abrasive becomes harder. The trade, however, judges the grading by the eye; that is, if all the grains of a size appear fairly uniform, the work is accepted as good. In this connection it is interesting to note that the firms who sell their products in the form of cloth and paper are not always so careful with their grading as those who, in addition, sell the different gradings loose. Where there is too much undersize in the grading difficulty is encountered in making it adhere firmly to cloth and paper.

TABLE I—SAND PAPER SIZES

Size	Mesh	
4	on 20	
3½	on 24	
3	on 30	
2½	on 36	
2	on 40	
1½	on 52	
1	on 66	
½	on 84	
0	on 108	
00	on 130	
000	on 147	
0000	on 164	
5/0	on 200	
6/0	on 240	Variations in the thread
7/0	on 240	
8/0	on 240	

[1] U. S. patent 1,011,196, Dec. 12, 1911, granted to Charles H. Hersey.

In addition to the sizes given in the tabulation, which are standard for all abrasives, finer sizes are produced in the following manner. At the Carborundum company's plant abrasives finer than 220-mesh are led to four conical settling tanks of 8, 18, 24 and 30-mesh top diameter, where the material settles in water, producing grades known as F, FF, FFF, and FFFF, according to the fineness, these grades being successively finer. Following this operation, the overflow of the last conical tank passes to liquor barrels, where it is allowed to settle for one minute, making the 1M grade. The material which has failed to settle is then siphoned into a second barrel and allowed to settle for four minutes, making the 4M grade. There is also an 8M and a 15M grade produced in the same way and by successive siphonings and settlements.

Abrasive Papers and Wheels

Abrasive grits are used in the free state attached to paper and cloth and in the form of wheels. In the manufacture of paper and cloth the fabrics are first sized and then rolled to remove creases. They are then hung on frames to dry, the frames being arranged so that they can be moved mechanically toward the gluing and sanding machines. The endless length of paper is supported on rolls, which form the top of the drying frame. Near the sanding machine the frame opens out and the paper is sprayed with steam. The paper or cloth then passes around rollers into a glue mixture, and thence under a shaking feeder, which sprinkles the proper size of grit upon the paper. From the sanding device the paper again passes to drying frames. After drying it may be made up into rolls or cut into sheets. At one establishment the grit is blown onto the paper, which is supposed to give it a better hold and at the same time present a better cutting surface.

In the manufacture of wheels a number of types are recognized, the principal one being the vitrified wheel. The chemical wheel is bonded with silicate of soda and some drying material, after which it is subjected to an oven heat for twenty-four hours. Other materials used for bond are shellac, linseed oil and rubber, the last yielding elastic wheels, and all being useful materials where very thin wheels are required. Vulcanite is also used as a bond and makes a very hard strong wheel, suitable for thin shapes where hardness and strength are required. The most common form of wheel is the vitrified wheel. In the manufacture various bonds are used, a suitable one for the purpose being a mixture of one part of ball clay with one part of feldspar, four parts of this mixture being used for each pound of abrasive grains. The hardness of the wheel is obtained by varying the composition of the bonding mixture. The wheels are molded wet, and when sufficiently dry to handle are trimmed and dressed to size and are then further dried. They are then burned in a kiln, the temperature being raised slowly, and the finishing temperature of 3000 deg. Fahr. is continued for several days. Several days again are required for lowering the temperature of the kiln. The different scales of hardness are shown in Table II.

TABLE II—SCALE OF HARDNESS OF ABRASIVE WHEELS

E—Soft	L	S
F	M—Medium	T
G	N	U—Hard
H	O	V
I—Medium Soft	P	W
J	Q—Medium Hard	X
K	R	Y and Z—Very Hard

Elastic Wheels are graded as follows:—1, 1½, 2, 2½, 3, 4, 5, 6, and 7. Grade 1 is the softest and grade 7 the hardest.

Vulcanite Wheels are furnished where extremely hard grades of very thin wheels are desired, particularly for operations requiring the wheel being run at excessive speeds and subjected to rough treatment.

The grits for wheels are of two kinds—the aluminous grits, emery, corundum, and the artificial oxides of aluminium, alundum, aloxite, etc., and carborundum. The aluminous grits are especially suited for grinding materials with a high tensile strength, and carborundum for materials with low tensile strength. The size grit to be used and the kind are indicated in Table III, published by the Norton company. Soft wheels are used on hard materials like hardened steel. On mild steel harder grades can be used. The area of surface to be ground in contact with the wheel is of the utmost importance in determining grade. A strongly bonded wheel must be used if it is a point contact like grinding a ball. If there is a broad contact softer grades must be used. Where there is much vibration harder wheels must be used than would be necessary if it were absent.

Table III—Selection of Grades

Class of Work	Alundum		Crystolon	
	Grain	Grade	Grain	Grade
Aluminum castings	36 to 46	3 to 4 Elas	20 to 24	P to R
Brass or bronze castings (large)			20 to 24	Q to R
Brass or bronze castings (small)			24 to 36	P to R
Brick, fire } off hand			16 to 20	O to Q
Brick, pressed } off hand			16 to 20	O to P
Car wheels, cast iron			16 to 24	P to R
Car wheels, chilled	20	Q	16 to 24	O to Q
Cast iron, cylindrical	24 comb.	J to K	30 to 46	I to L
Cast iron, surfacing	16 to 46	H to K	16 tc 30	I to L
Cast iron (small) castings	24 to 30	P to R	20 to 30	O to S
Cast iron (large) castings	16 to 20	Q to R	16 to 24	Q to S
Chilled iron castings	20 to 30	P to U	20 to 30	Q to R
Dies, chilled iron			20 to 30	O to Q
Dies, steel	36 to 60	J to L		
Drop forgings	20 to 30	P to R		
Hammers, cast steel	30	P to Q		
Holloware, inside grinding			30	O
Holloware, thin edges			24	U
Internal grinding of automobile cylinders (cast iron)			36 to 60	I to L
Internal grinding, hardened steel	46 to 60	J to M		
Knives (paper), automatic grinding	36 to 46	J to K		
Knives (planer), automatic grinding	30 to 46	J to K		
Knives, leather shaving	60	N to O		
Knives, leather splitting	24 to 30	1 to 2 Elas		
Knives, moulding bits, etc	46 to 60 46 to 60	3 Elas. M		
Knives (planing mill), hand grinding	46 to 60	J to M		
Knives, shear and shear blades	30 to 60	J to M		
Knives, shoe	60	M		
Lathe centers	46 to 120	J to M		
Lathe and planer tools	20 to 24 20 to 36	P Sil. O to P		
Machine shop use, general	20 to 36	O to Q		
Malleable iron castings (large)	14 to 20	P to U	16 to 20	R to S
Malleable iron castings (small)	20 to 30	P to R	20 to 30	Q to S
Marble, finishing	180 to 200	I		
Marble, roughing			16 to 46	J to M
Marble, coping			14 to 24	5 to 7 Ela
Marble, moulding			36 to 46	L to M
Milling cutters, automatic or semi-auto, grinding	46 to 60	I to M		
Milling cutters, hand grinding	46 to 60	J to M		
Nickel castings	20 to 24	P to Q	20 to 24	R
Pearl grinding, roughing			30 to 50	P to U
Pearl grinding, finishing			100 to 150	M to P
Plow bodies (cast iron), surfacing			24	R
Plows (steel), jointing	20 to 24	R to S		
Plow points (chilled iron), surfacing			20 to 30	Q to S
Plows (steel), surfacing	16 to 24	Q to S		
Porcelain, roughing			36 to 50	O to R
Pulleys (c. i.), surfacing faces of			30 to 36	K to L
Radiators (cast iron), edges of			24 to 30	R to S
Razors, grinding, concaving	46 to 120	H to O		
Reamers, taps, milling cutters, etc., hand grinding	46 to 60	K to O		
Reamers, taps, milling cutters, etc., special mach's	46 to 60	J to M		
Rolls (cast iron), wet	24 to 36	J to M	24 to 46	J to M
Rolls (chilled iron), finishing	70	1½ to 2 Elas.	70 to 80 80	1½ to 2 Elas. J
Rolls (chilled iron), roughing			30 to 46	2 to 5 Elas
Rubber	30 to 50	J to K	30 to 50	K to M
Sad irons, finishing			80 to 120	O to R
Sad irons, roughing			20 to 30	Q to S
Saws, gumming, sharpening	36 to 50	M to N		
Saws, cold cutting-off	60	O to Q		
Shovels, edging	24	Q		
Spiral springs, ends of	16 to 20	Q to R		
Steel (soft), cylindrical grinding	24 com. 30 to 60	L to P L to O		
Steel (soft), surface grinding	16 to 36	H to K		
Steel (hardened), cylindrical grinding	24 com. 46 to 60	K J to L		
Steel (hardened), surface grinding	16 to 46	H to K		
Steel, large castings	10 to 20	Q to W		
Steel, small castings	20 to 30	P to R		
Steel (manganese), safe work	16 to 46	L to P		
Steel (manganese), frogs and switches	14 to 16	Q to U		
Structural steel	16 to 24	P to R		
Stove castings	20 to 36	P to Q	20 to 36	Q to R
Twist drills, hand grinding	46 to 60	M		
Twist drills, special machines	36 to 60	K to M		
Wagon springs, ends of	20 to 30	P to R		
Wire, ends of steel	36 to 80	Q to R		
Wrought iron	12 to 30	P to U		
Woodworking tools	46 to 60	K to M		

Miscellaneous Graded Materials

Asbestos

Over 80 per cent of this material comes from Canada, the production of other countries being unimportant. The asbestos mines of Canada are located in the eastern townships of the Province of Quebec. The most productive localities are at Thetford, Black Lake and Danville. The asbestos mined is the long-fibered variety or chrysotile. The best of it is obtained from hand-sorting, and represents fiber over an inch in length suitable for spinning.

In the milling of the quarried material, which cannot be separated by hand, the rock, after crushing, is subjected to a fiberizing operation; that is, one tending to fluff it, and this is followed by air separation to lift the fiberized asbestos, and by screens to remove the impurities. The production and value of sorted and mill products for 1913 is shown in Table IV, taken from Mineral Industry. The asbestic product at the bottom of the table is the finest in size and has associated with it much impurity. The rock is crushed by rotary beater crushers.

Table IV—Output, Sales, and Stocks of Canadian Asbestos in 1913, in Short Tons

	Output	Sales			Stock on Hand Dec. 31		
	Quantity	Quantity	Value	Price per Ton	Quantity	Value	Price per Ton
Crude No. 1	2,015.4	1,853.3	$31,200	$286.62	880.5	$247,877	$281.52
Crude No. 2	3,010	3,807	457,962	120.29	1,522	178,789	117.49
Mill stock No. 1	23,444	26,198	1,229,908	46.95	6,755	350,165	51.84
Mill stock No. 2	58,592	60,164	1,201,215	19.97	4,809	108,285	22.52
Mill stock No. 3	45,503	44,929	410,624	9.14	6,820	54,604	8.01
Total asbestos	132,564.4	136,951.3	3,830,909	27.97	20,786.5	939,720	45.21
Asbestic	.....	24,135	19,016	.79	.....	.....	.....

Barytes

This substance is obtained from the mineral "heavy spar" by grinding the cleaned and sorted material, bleaching it by boiling in acid until the iron and other staining constituents are removed, washing with distilled water, grinding again in buhr mills to the requisite fineness, and grading by elutriation in water. The commercial grades of the mineral carry from 95 to 98 per cent of barium sulphate and 1 to 3 per cent silica. Crude barytes sells for $3 to $4 per ton. The principal producers in the United States are located in Missouri. Refined barytes sells for about $13 per ton. The annual production of crude barytes is about 40,000 tons. Beyond its use as an adulterant and filler for giving weight, barytes has an important use in the manufacture of lithopone, a white pigment of zinc sulphide and barytes. For white rubber goods barytes is used either direct or in the form of lithopone.

Borax

The principal deposits of the world's supply of borax are found in the Death Valley district, Inyo County, California. Borax was first obtained from natural waters, from which it was extracted by evaporation. In California the first discovery of this type was made by Dr. John A. Veatch in 1859 at Clear Lake, Lake County, about 80 miles due north of San Francisco. The lake water contained about 7.63 per cent salts, of which over 5 per cent was boric acid. In Europe the principal source of borax and boric acid is the condensed

watery vapor of volcanic fumaroles in the province of Tuscany, Italy. Following the obtaining of boron products from evaporation of waters a more plentiful supply was obtained from the bottoms of dry lakes or marshes. Deposits of this kind on the Nevada-California border yielded the entire output of borax from that region for many years. The final stage in the development was the discovery of colemanite, a borate of lime containing in the pure state 50 per cent of boron trioxide, in Death Valley, Inyo County, California. The present production of borax and boracic acid is derived wholly from this substance. The colemanite occurs in a form which up to recently was described as a bedded deposit, but of late years geologists have leaned to the view that the deposits are true veins and are a phase of vulcanism. The borax deposits of California are lagely under the control of the Pacific Coast Borax Company, which is to-day a subsidiary of Borax Consolidated of London.

In the refining of borax the colemanite rock is first treated at the mine to remove impurity, and roasted to drive off the water of crystallization. It is then shipped East to the refinery at Bayonne, N. J. On reaching the works the ore is again crushed and put through grinding mills. Colemanite is readily decomposed by carbonate of soda, forming borax, or by dilute acids which, on concentration of liquors, yield boracic acid. The crystallizing vats at Bayonne are rectangular in shape, and surface for crystallization is obtained by suspending wires in them. The borax and boracic acid which crystallize on the sides of the vats are imperfect and have to be recrystallized. Following the crystallization the boron products are screened into a large number of sizes. The imperfect crystals forming the undersize of the finest screen are ground in revolving crushers, the impalpable sizes resulting from this operation and from settlement in dust chambers being much used by manufacturers of foot powders. Finely powdered boracic acid is much used by manufacturers of talcum powders. The coarsest crystalline size is used in the enameling trades, this being about pea size; then successively come domestic and pharmaceutical sizes. As is well known, borax makes a clear-colored glass with metallic oxides and reduces the temperature of melting other compounds mixed with the oxides and borax in making enamels.

Canning

Peas are the only canned product which is graded. But some historical matter which will apply to all may be of interest. The first invention relating to canning is that of M. Appert, who secured the prize of 12,000 francs offered by the French government for a method of preserving food for the use of the navy. The complete methods as disclosed by him in a work published in 1819 form the basis for modern canning processes. In brief, Appert's discovery was to heat the material to the temperature necessary to kill all organisms present, and make possible preservation for an indefinite period by hermetically sealing the package. Appert chose glass to hold the food. In 1810 an Englishman took out a patent covering vessels made of metal. The introduction of the tin-coated can, with its cheapness and strength, is what has made possible the enormous size of the canning industry to-day. Among the first to use the method in the United States was Thomas Kensett who, in connection with Ezra Daggert, engaged in the canning business in 1819. The real rise of the American canning industry dates from 1850, from which date the volume of the business began to swell very rapidly. During the eighties of the last century the business fell into disrepute with the public owing to the flooding of the market with inferior products. Practically every canner is to-day a member of a national association which maintains a laboratory where individual failures are analyzed and the proper temperature, etc., for canning individual products are thoroughly studied, and the results distributed freely to the members of the association. Corn, which offers much difficulty in preserving, was first successfully put out by Isaac Winslow in 1842.

Tomatoes were first packed for commercial purposes about 1847, not because they offered any particular difficulty prior to that time, but because the value of the tomato as a food product was not appreciated earlier.

A description of the canning of peas will serve to illustrate the general steps employed for canning all articles. In the beginning of the pea-canning industry the peas were picked and shelled by hand. This was followed by the invention of the pea huller, a machine which was capable of hulling 1000 bushels of peas in ten hours. This machine was superseded by a form of pea thresher, which shells the whole vines. At present the peas are moved and carried to the factory, where they are fed into the pea thresher or viner. Following the shelling operation the peas pass through the separator, the operation of which is the same as in grain separating. The first separation takes out leaves, sticks, etc. The final separation removes the adhering sand and dirt. These machines will not, of course, separate any impurity in pieces within the range of the size of peas. Following the separator the peas pass through revolving screens, which will be in number to suit the fancy of the individual packer. The size aperture will also depend to some extent on the district, variety grown and the season. Some seasons are favorable to the rapid growth of the size of the pea in the pod, yielding a large quantity of large peas. The packers incline rather to a medium-sized pod rather than a well-distended pod with a large percentage of large peas, for which as good a price cannot be obtained as for a smaller pea. There are usually three sizes made, the little or French pea, the medium-size pea and the large or telephone variety.

Screening for peas differs from ordinary screening in that the smallest pea is removed in the first screen and successively larger sizes on the lower screens. Following the grading operation the peas are hand-picked for removing imperfect and off-color peas, bits of leaf, etc. They are next washed and cooked for a few minutes before putting into the cans. Following the preliminary cooking they are rinsed in cold water and drained, after which they are weighed into the cans. The cans are filled with syrup, the proportion of sugar being varied according to the amount in the pea. Following the canning operation the peas are steamed and then capped. After the capping process the small steam hole is filled with a drop of solder. The cans are then heated to a degree and for a length of time sufficient to destroy all germs in a steam process kettle. The heating of the pea has to be rather carefully regulated, for too high a temperature will break down the structure, make the pea mushy and the syrup cloudy. Too low a temperature will, of course, not give the proper germ-destroying result.

California is to-day the most important canning State, but at the last census Wisconsin led in the canning of peas, the value of the Wisconsin product in 1909 being over $3,000,000. New York was next at that time, with a valuation of over $2,000,000. In the matter of rank such statistics are not of much value, as there are very marked changes in this respect from year to year.

Calcium Carbide

This material is sent out in a multitude of grades, from pieces 4 in. in diameter, used for marine gas

buoys, down to 35-mesh. Below this size it is difficult to grade without producing too much powder that would yield too rapid an evolution of gas.

Cement

There is at present no grading problem in this industry. The methods of manufacture are too well known to go into.

Denver, Colo.

The Making of a Big Gun

Faraday Society Meeting

Dr. W. **Rosenhain,** of the (British) National Physical Laboratory, delivered on April 6 an illustrated lecture under the auspices of the Faraday Society on "The Making of a Big Gun." The lecture was held at the Royal Society of Arts in London.

The lecturer began by contrasting the "big guns" of olden times with the gigantic weapons of to-day. The older guns were made of cast iron, and guns of that material reached their highest development in the American Civil War. The conditions existing in modern guns were illustrated by sectional diagrams relating to guns of fairly recent date, in which pressures of 18 tons per square inch and muzzle velocities of 2500 feet per second occurred. To resist these conditions, the best possible steel was required, and even that only served for a comparatively short time. The work of modern guns was illustrated by some photographs of gigantic projectiles which had been recovered intact after penetrating great thicknesses of modern armour. The effect of use on the inside of a gun was illustrated by photographs showing the "erosion" and the cracking which occur as the result of the high temperature of the explosion gases.

The lecturer then proceeded to describe the modern process of gun-making by the aid of a series of cinematograph pictures of the most interesting and striking stages of the process. These films had been prepared and lent by Messrs. Vickers, Ltd., at whose Sheffield works they had been taken. The series began with the blast-furnaces in which the iron ore is reduced by the aid of coke and limestone; next came the open hearth steel furnace and the processes of filling were shown, and particular attention was drawn to a picture which clearly showed the "boiling" of the molten steel within the furnace. Throughout the various stages of the process, including the refining of the iron to transform it into steel, its various stages of forging, hardening, and tempering, the lecturer gave in popular terms the scientific reason for each step, illustrating his remarks by a series of photomicrographs showing the minute structure of the steel at each stage, and showing how each step served to bring the steel nearer to the ideal condition of perfect homogeneity. The lecturer naturally avoided reference to those confidential matters which relate to the most recent products of the steel-maker's art as directed to the production of guns, but as an indication of the direction in which modern practice tended, he showed the extremely minute micro-structure which can be produced by proper treatment in modern special or "alloy steels." The extreme importance of accurate scientific control, of compositions, temperatures, and rates of cooling, throughout the process, was strongly emphasized and illustrated.

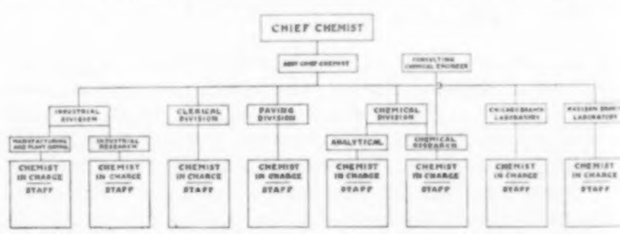
By means of the series of cinematograph films the gun was followed through its various stages, from the freshly cast ingot weighing 80 tons, through the processes of "cropping" and "trepanning," as the first piercing of the ingot to form a rough tube is called, on through the forging press until it attains its requisite length—in some cases over 70 feet. Then follow the machining operations, and then what is, perhaps, the most delicate part of the process—hardening and tempering, in which the roughly machined tube is heated to a uniform and carefully regulated temperature in a tall chimney-like vertical furnace, from which it is lifted at the proper moment to be plunged into an oil-bath contained in a deep cylindrical well. The process of rifling and the finishing of the outside, after the application of the wire-winding, were also shown. Finally, as a relief to the more severely technical portions of the lecture, some films were shown illustrating the testing and firing of big guns.

The President of the Faraday Society, **Sir Robert Hadfield,** in proposing a vote of thanks to the lecturer, supplemented what he said by some further interesting information with regard to the achievements of modern artillery. He spoke, for example, of 16-in. American guns firing a shell of 2400 lb. weight a distance of 21 miles, and of 12-in. armour plate fired at from a distance of 1½ miles being cracked but not perforated. The wire-wound gun described by the lecturer was found to be the finest in the world, and it had the advantage of being cheaper than enemy patterns. It was not usually realized that the life of a large gun, based on the time of actual fire, was not more than three seconds.

A curious fact was that the soft-nosed cap used on modern shell expanded so rapidly on striking an object as to allow the complete shell to pass through it. In referring to the great importance of metallurgy in gun-making engineering, Sir Robert Hadfield told of a 15-in. shell which can pass through 15-in. armour plate in no more than 1/000 of a second, and of a 6-in. shell fitted with a modern cap which he had seen fired three times before the shell was broken.

Laboratory Organization of an Asphalt Company

Below is a chart showing the organization of the laboratory forces of The Barber Asphalt Paving Company, the work of which was described in METALLURGICAL & CHEMICAL ENGINEERING of May 1, under the title of "A Company that Makes the Most of Its Chemists."



The special duties of each division of the laboratory were described in the article just referred to.

The first annual convention of the **American Association of Engineers** was held in Chicago, May 9 and 10. Two afternoon informal sessions were held in the rooms of the Western Society of Engineers, 1733 Monadnock Block. The annual dinner was held at the City Club. No long papers were permitted at the informal sessions, but discussions of several vital subjects were made by prominent engineers.

Testing Volumetric Apparatus.—A bulletin has been issued by the Bureau of Standards (Circular No. 9) entitled "The Testing of Glass Volumetric Apparatus," containing specifications and tolerances for such apparatus and also a short description of methods of test.

The Chemical Analysis of Rubber Goods

BY ANDREW H. KING

Under this head comes some of the most difficult work the analytical chemist has to perform. Most of the difficulties are due to the colloidal nature of rubber, and to the fact that there is no simple, easy and direct method for the determination of the rubber content. Obviously one very important question in regard to any sample is: "How much rubber is present?" To answer this we must use various indirect methods, and their accuracy is sometimes in doubt.

In the early days of the rubber industry it was customary to determine the rubber content by difference. This was done by adding the mineral matter (determined by ashing) and the total sulphur, and subtracting the sum from 100. It is hardly necessary to state that this method was quite crude and inaccurate. For example, many substances such as substitute, oils, ground leather, etc., could be used to replace considerable percentages of rubber without detection. To remedy this condition recourse was had to various extractions, with such solvents as acetone, chloroform, alcoholic potash, and water. By a proper interpretation of these results, correction can be made for adulterants, and a reasonably correct figure for the rubber content obtained.

It was found, however, that variable extracts could be secured from the same sample by the use of different forms of extractors, and by varying the conditions of extraction. For example, a sample of fire hose may show an acetone extract of 2 per cent in a Soxhlett, but when extracted in the Underwriters' form, at the boiling point of the solvent as much as 2.5 per cent may be secured. This variation seems to be due to the colloidal nature of the rubber hydrocarbon, owing to the difference in adsorption under various conditions.

Because of the variations in the several extracts, attempts have been made to standardize the practice. Perhaps the best of these standard methods of rubber analysis are those of the Bureau of Standards, the Joint Rubber Insulation Committee, and the Underwriters' Laboratories of Chicago. These methods have been evolved for specification work, and the rubber chemist usually modifies them according to his own needs.

In this article I will endeavor to set forth a satisfactory procedure for general work. The methods given are, in my opinion, the most satisfactory of those published, and no claim for originality is made. It is my aim to place in the hands of the chemist not connected with the rubber industry, a tool which will enable him to satisfactorily differentiate between a good and a poor article. Proper inspection of a shipment of rubber goods demands both physical and chemical testing. The former shows the present state of the material, and by the latter we can predict as to its condition in the future.

Preparation of Sample

It should be the aim of the chemist to see that the sample he analyzes is not contaminated by any foreign material. In other words, that it is a true sample. For example, an analysis of a fire hose tube should be made on the tube alone; that is, with the backing buffed off. The clean sample must then be finely divided. This is best performed by passing it through the rolls of a small mixing mill. The Underwriters' Laboratory uses a motor-driven mill, having rolls 6 in. x 12 in., the front roll smooth and the drive roll corrugated. In the absence of a mill, a food chopper can be used to advantage. In the case of hard rubber, the sample is prepared by rasping with a file.

Reagents

Acetone should be freshly distilled over anhydrous potassium carbonate, using the fraction 56 to 57 deg. C. Technical acetone may be purchased and purified as above. The residue on evaporation must be negligible.

Chloroform should be the purest obtainable, the grade used for anesthesia is satisfactory.

Ether specifications are the same as for chloroform.

Alcoholic potash should be of normal strength, and may be prepared by adding just enough water to the required weight of potassium hydroxide (C.P. by alcohol) to dissolve it. This solution is added to the desired quantity of alcohol, which has been previously boiled for two days under a reflux condenser with sodium hydroxide, and later distilled. When completed, the resulting solution should contain approximately 95 per cent alcohol by volume.

Water used is best double distilled, neutral to litmus paper, and should show no weighable residue on evaporation of 500 c.c.

All other reagents should be C.P.

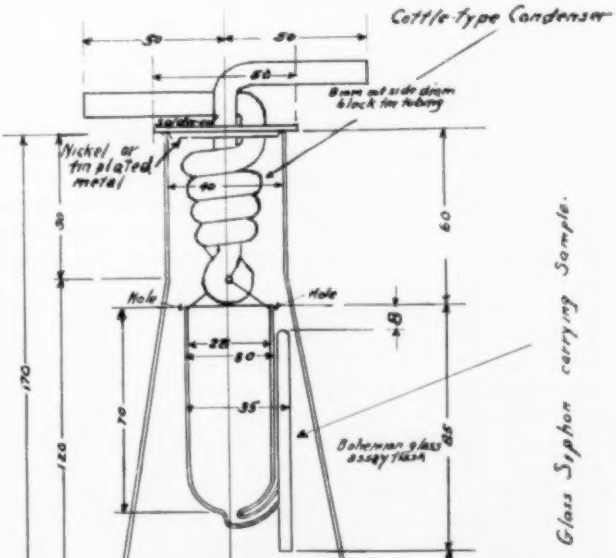
Determinations

The determinations made in a complete analysis are as follows:

1. Acetone extract. (*a*) Free sulphur. (*b*) Waxes.
2. Chloroform extract.
3. Alcoholic potash extract.
4. Water extract.
5. Total sulphur.
6. Ash and mineral analysis.
7. Total fillers and rubber.
8. Specific gravity.

It is not always necessary to make every determination. The chemist must use his own judgment as to the demands of the particular case he has in hand.

Acetone Extract.—A 2-gram sample is wrapped in cloth, which has been previously treated with acetone to remove vegetable waxes, and the whole extracted over night with 50 to 60 c.c. of acetone in a weighed flask. This applies only to soft rubbers. Hard rubber samples must be extracted for three successive days. The acetone is



All dimensions in millimeters

Fig. I

Joint Insulation Committee Standard Extraction Apparatus.

then distilled off, and the flask dried to constant weight in an oven, at 95 to 100 deg. C. Cool in a desiccator, and weigh. When the extract is to be examined for waxes, etc., it is best to use that from the 2-gram sample for the determination of the free sulphur, and to separately extract a 5-gram sample. When the bulk of the 5-gram sample is such that the extractor will not hold it, it may be divided into two portions, and run over two nights. The apparatus used, Fig. 1, is that recommended by the Joint Rubber Insulation Committee.

The extract so secured contains the natural rubber resins, the free sulphur, and any added resins, oils, or waxes. It also contains a portion of any tar or asphaltic material, such as mineral rubber, when present. Most organic vulcanization accelerators are soluble in acetone, and are to be found in this extract.

The acetone extract is one of the most important determinations made. Properly interpreted, it aids greatly in showing just what has been added to the compound in the course of manufacture. The color of the extract is a good indication. From high-grade compounds the extract should never be darker than a light straw color, and the net extract, that is, after subtracting the free sulphur, should not exceed 5 per cent. Mineral oil, tar, or asphaltic material causes a fluorescent extract. When present in quantity they darken the color to a brownish black. Even a small percentage serves to give fluorescence. This is an additional indication of the presence of shoddy, which very frequently contains mineral oil in the form of vaseline, which is added to make the material more plastic and workable.

When a determination of the wax is desired, the extract from the 5-gram sample is used. This is accomplished by the method of Weber. The dried extract is warmed with about fifty times its weight of glacial acetic acid. On cooling, paraffine wax separates almost quantitatively, and can be filtered off and weighed. A partial separation of the various constituents of the acetone extract may be accomplished by the use of absolute alcohol according to the following scheme. Allen, Commercial Organic Analysis, Vol. IV, page 124.

Separation of the Acetone Extract by Means of Alcohol

Soluble	Insoluble
Free fatty acids	Fatty and mineral oils (except castor and blown oils)
Resins (colophony)	Tar oils, solid hydrocarbons
Waxes (beeswax, carnauba)	
Castor and blown oils	

The extract is warmed with absolute alcohol, filtered from insoluble matter; on cooling below 0 deg. C. the soluble waxes are precipitated. Considerable work is yet to be done at this point, for there is no entirely satisfactory method for the separation and quantitative estimation of the different constituents of the acetone extract.

Frequently considerable stress is laid upon the determination of the saponifiable matter. That is accomplished in the same general manner subsequently described under the alcoholic potash extract, except that the soap solution is not acidified. The dried acetone extract is covered with about 30 c.c. alcoholic potash and boiled for five hours, using the Cottle condenser. The solution is filtered, and any residue washed with alcohol and hot water. The filtrate is evaporated to small bulk, diluted with cold water, and shaken with ether in a separatory funnel. The ether extract is washed once with water, and the ether evaporated from a weighed flask. On drying and weighing, a measure of the unsaponifiable matter is obtained. In a high-grade article, where no organic fillers have been added to the mixing, this figure is indicative of the kind of rubber used. It serves also to indicate the amount of fatty oils present. The Joint Rubber Insulation Committee allows 1.35 per cent saponifiable acetone extract on 30 per cent rubber insulation.

Free Sulphur.—The term "free sulphur" is really empirical. On the surface it would seem to mean uncombined sulphur, as opposed to the combined, that is sulphur of vulcanization. When vulcanization was first investigated from a scientific standpoint, the samples were extracted with acetone, and the sulphur determined in the extract. This figure they called free sulphur. Soluble, or extractable sulphur, would have been more appropriate. The extractor first used was the Soxhlett. As the reader will recollect, in this form the solvent is contained in a flask which rests on a water bath. On boiling, the vapors pass up through a side tube to the extractor, and from there to the condenser, where they are condensed. The liquid falls upon the sample, which is contained in a paper thimble in the extractor. When the level of solvent reaches a certain height, the siphon tube is filled, and the solvent flows back into the original flask. It is obvious that the solvent in the extractor is comparatively cold. On reference to Fig. 1 it will be seen that the solvent which comes in contact with the sample in the Insulation Committee form is at a much higher temperature. In fact, the liquid in the siphon cup is nearly always boiling. So in speaking of this form, extraction is said to be made at the boiling point of the solvent. Practically all commercial acetone extracts are now made in this manner. As a matter of scientific interest, the work of Skellon (Proceedings International Rubber Congress, 1914, London) should be mentioned. By extracting under pressure, he was able to obtain a higher temperature of solvent, and thus remove still more sulphur from a sample previously extracted as above described. Evidently the end is not yet, and much work must still be done before we can determine for a surety the true percentage of free sulphur, and as a corollary, the amount of combined sulphur.

The extract from the 2-gram sample, which has been previously dried and weighed, is treated with 10 c.c. fuming nitric acid. Warm on the water bath. When solution is complete, add 1 gram of powdered anhydrous potassium chlorate, and run nearly to dryness. Add 5 c.c. concentrated HCl, and run to dryness; repeat to expel any remaining nitric acid. Take up with hot water, acidify slightly if necessary with HCl. If the solution is cloudy, filter. Heat to boiling, and add a boiling solution containing 10 c.c. of 10 per cent barium chloride solution diluted somewhat with water. Let stand over night, filter, ignite, and weigh.

In many kinds of mechanical goods the free sulphur is not overly important. In high-grade articles it should be less than 1 per cent in order to age properly. In making a non-blooming gray inner tube, the aim is to keep the free sulphur below one-half of 1 per cent. By blooming is meant the formation of a surface scum of finely divided colloidal sulphur. When the free sulphur is high, the colloidal particles coalesce into well-defined sulphur crystals. Articles that are to be subjected to relatively high temperatures must have a low free sulphur (less than ½ per cent), so that they will not become brittle. For example, the cover of a belt conveyor, designed to carry hot clinker, must be so compounded that the free sulphur will be very low, otherwise the rubber will be vulcanized beyond the point of its greatest elasticity, thus causing surface hardening and ultimate failure.

Chloroform Extract.—The same apparatus as previously described under extraction with acetone is used for chloroform. It is not necessary to dry the acetone extracted sample, but only to squeeze out the excess.

The sample is extracted for four hours with 50 c.c. of chloroform. If after this time the solvent in the extractor siphon is still colored, the extraction is continued until clear, and one hour thereafter. The chloroform is distilled off, and the flask dried to constant weight in an oven at 98 to 100 deg. C.

High-grade material will give an almost colorless chloroform extract, and not over 1½ per cent on a 45 per cent rubber compound. Less valuable articles will give a higher extract, having a yellow color. A brown to dark brown extract is indicative of mineral rubber, tar, or other asphaltic material. The behavior of mineral rubber is worthy of mention. Ordinarily it is partially soluble in acetone, and entirely so in chloroform. But upon mixing with sulphur and the other ingredients of a rubber compound and vulcanizing, a portion of the mineral rubber becomes insoluble in both acetone and chloroform. As yet we have no accurate method of determining the percentage of this substance after vulcanization.

Alcoholic Potash Extract.—The sample, following the chloroform extraction, is removed from its cloth sack and dried for one-half hour in an oven at 50 to 60 deg. C., or allowed to stand over night at room temperature, to free it from chloroform. It is then placed in an extraction flask with 50 c.c. normal alcoholic potash solution. The Cottle condenser is put in place and boiling is continued for four hours. At the end of this time the flask is emptied upon a filter, washed with at least 50 c.c. of hot absolute alcohol, and following with hot water. The filtrate and washings are evaporated on the water bath until the volume is reduced to about 20 c.c. Distilled water is added to bring up the volume, and the whole poured into a separatory funnel, where it is just made acid with dilute HCl and 3 c.c. excess. This solution is shaken out with ether, using 20 c.c. portions until the ether layer is clear, then three times thereafter with 10 c.c. portions of the solvent. The ether extracts are combined, washed once with water, and placed in a weighed flask. The ether is distilled off, the flask dried at 98 to 100 deg. C. to constant weight. On good material (50 per cent rubber) the alcoholic potash extract should not exceed 1½ per cent. A high extract indicates the presence of rubber substitute. Its use is permissible only in low-grade articles. The extract contains the fatty acids of the oils in preparing the substitute. These may be taken as representing approximately 80 per cent of the total percentage of substitute present.

Water Extract.—Sometimes such substances as starch and dextrine are added as a filler. When such are thought to be present, a 1-gram sample is placed in a cloth sack and boiled with distilled water for four hours. The sack is removed and any absorbed liquid squeezed out. The solution is evaporated to dryness, and weighed. The determination of water extract is now almost unnecessary, since water soluble fillers are avoided as much as possible in compounding.

Total Sulphur.—There are many methods proposed for the estimation of total sulphur, but the Bureau of Standards' modification of Henriques method seems to give more uniformly accurate results.

A ½-gram sample is placed in a porcelain crucible of about 100 c.c. capacity. A nitric acid bromine mixture is prepared by saturating concentrated nitric acid with bromine and allowing it to stand some hours before using; 20 c.c. of this mixture are added gradually to the contents of the crucible. Let stand for one hour, then place on the water bath and heat for another hour, rinse off the cover, and evaporate to dryness. Add 5 grams of fusion mixture, which is prepared by mixing equal parts sodium carbonate and potassium nitrate, and 3 to 4 c.c. of water. Digest for a few minutes, and spread the mixture half way up the sides of the crucible to facilitate drying. Run to dryness on the water bath. Fuse, using a sulphur free flame, and continue heating until all organic matter has been destroyed and the melt is plastic. Allow to cool, place the crucible in a 600 c.c. beaker, cover with distilled water. Digest on the water bath until solution is complete. Filter into an 800 c.c. beaker, washing thoroughly with hot water. The total volume should be around 500 c.c. Acidify with concentrated hydrochloric acid and boil. Add 10 c.c. 10 per cent barium chloride solution as under the determination of free sulphur. Let stand over night, filter, ignite, and weigh.

The total sulphur reported by this method includes the sulphur added to the compound in mixing, and also that of any sulphur-bearing fillers, such as barytes, lithophone, gypsum, etc. Therefore proper correction must be made before the added sulphur can be estimated. This is best done by taking the separated total fillers secured by the method later to be described, and treating this sample, with a few cubic centimeters of the nitric acid bromine mixture. Run to dryness, and fuse with 5 grams of the standard fusion mixture, according to the method given above. It is, to my mind, a waste of time to determine the percentage of sulphur present in the ash, since more or less of the sulphur present, even the combined sulphur, is taken up by any litharge present, forming lead sulphate. Zinc oxide is partially converted to zinc sulphate.

Ash and Mineral Analysis.—This determination was formerly given considerable weight. While it is important, and will at times give valuable information, there are certain factors which must not be lost sight of.

The method is as follows:

A 1-gram sample is wrapped in a piece of 589 filter paper, and extracted over night with acetone in the regular manner, thus removing the free sulphur. The sample is then dried and ignited in a weighed porcelain crucible. The ignition is best performed in an electrically heated muffle. When such is not available, an Argand burner may be used. The temperature should be so regulated that there are no visible fumes, and the heat gradually increased until all the carbon is burned off. The time of ashing should not be unduly long; six hours seems to me about the maximum. Longer ashing will lead to the formation of considerable lead sulphate, so that the figure for ash will be much too high. The temperature of the crucible should always be as low as possible, so that no carbonates will be decomposed. When vermillion, antimony golden sulphide, or carbon are present, the ash determination is no longer a measure of the fillers, since these substances are wholly or partially volatilized. A sample of rubber which is to be analyzed for antimony or mercury is best dissolved by the following method:

A ½-gram sample is oxidized with 10 grams ammonium persulphate and 10 c.c. fuming nitric acid in a 100 c.c. flask. After the principal reaction, which takes place in the cold, has ceased, the flask is carefully heated. If after fifteen minutes' digestion red particles of mineral or organic matter are still visible, 3 grams more of ammonium persulphate are added. Too strong heating must be guarded against, as this tends to produce insoluble combinations. After heating, the flask is allowed to stand until crystals begin to form, when 10 c.c. concentrated hydrochloric acid are added. After solution takes place, it is diluted with hot water, and the insoluble matter filtered off. Proceed from this point according to the customary analytical methods.

When an analysis of the ash is desired, it is made

according to the usual practice of quantitative analysis. The following list includes most of the fillers ordinarily added to a rubber compound:

Silica.

Iron and aluminium oxides and silicates.

Barytes.

Lead in the form of litharge, basic or sublimed white lead.

Zinc in the form of oxide or sulphide in lithophone.

Lime and whiting.

Magnesia and magnesium carbonate.

Antimony in the form of golden sulphide.

In cases where pigments have been used, only the dry colors and lakes need be looked for. For example, a green color will usually be due to chrome green, a blue to ultramarine. Red is secured by vermillion, iron oxide, or antimony sulphide. Copper and manganese should never be present.

The advantage of the ash determination is that the rubber content may be arrived at quickly by adding the ash and the net total sulphur (total sulphur minus inorganic sulphur), and subtracting the sum from 100. By making proper corrections, according to the amounts of the various extracts, a more nearly correct figure may be reached.

Total Fillers.—When a more nearly accurate figure for rubber is desired, or in the presence of vermillion, lamp black, etc., recourse must be had to other methods. There are several direct methods proposed for the determination of rubber, but they are rather complicated and require so many corrections that none can be called entirely satisfactory. Another way of approach is to dissolve out the rubber by means of a suitable solvent, and filter off the total fillers. In this manner such fillers as ground leather, cotton waste, etc., are not lost as they would be in ashing.

A satisfactory method for this determination follows:

A 1-gram sample is placed in a 400 c.c. flat-bottomed flask and covered with 50 c.c. purified nitrobenzole. This is connected to an air-cooled reflux condenser. If ground glass joints are not available, cork, covered with tinfoil, may be used. Begin digesting very slowly on the water bath to avoid carbonization. Finally heat to the boiling point of the solvent. Continue the operation until the sample is decomposed. Cool, fill the flask with acetone, and allow to settle. Filter through a weighed filter paper, washing with acetone. Dry, and weigh.

When lamp black or other organic matter is to be determined, treat the filter paper carrying the residue with hydrochloric acid to decompose any carbonates. Filter, using a weighed paper. Dry, and weigh. Calculate the loss due to carbon dioxide, and ignite in a porcelain crucible, as under ashing. The loss will be organic matter.

By this method the percentage of total fillers is secured. Oils, dopes, etc., must be estimated from the extracts. In filtering the rubber solution there are difficulties, since the rubber colloid exerts a protective action, thus preventing a rapid settling of the mineral fillers.

By dividing the percentage of net acetone extract, that is, minus the free sulphur, by the percentage of rubber, a figure is secured which when multiplied by 100 is called the resin on rubber. When no organic fillers have been added to the compound, this figure aids in saying what kind of rubber has been used. For example, the resin on rubber of Plantation Smoked Sheets varies from 2½ to 4½ per cent, while that of Coarse Para varies from 1 to 2½ per cent. A high resin on rubber indicates added resins, oils, or waxes, low-grade rubber, or shoddy.

The coefficient of vulcanization is obtained by subtracting the free sulphur from the added sulphur, and dividing this figure by the percentage of rubber and multiplying by 100. It shows the ratio of combined sulphur to rubber substance. This ratio varies, depending upon the kind of material being prepared. Thus, for inner tubes, it is usually around 2.5. For fire-hose tubing it is around 4.0, hard gaskets and valves 10 to 20, and for the highest possible vulcanized condition it is 32. The presence of shoddy increases this ratio, thus a shoddy hose may have a coefficient of vulcanization of 10 or 12, and still remain elastic. In general, shoddy is indicated by high coefficient of vulcanization, a high resin on rubber, and a fluorescent acetone extract.

Let me repeat what I said in a previous article—the presence of shoddy is not necessarily a basis for condemnation. Fit the material to the purpose, for high duty use high-grade rubber, for easier conditions use the poorer variety.

Specific Gravity.—The specific gravity of a sample was at one time given considerable weight, due to the idea that of two samples the one having the lower gravity contained the most rubber. The inaccuracy of this does not require demonstration.

The determination is made according to Archimedes' principle, weighing first in air and then in water. Divide the weight in air by the loss of weight in water for the gravity. Use a sample of 3 to 5 grams, and take care that all air bubbles are removed before weighing in water. Perhaps the best compounds have a gravity of 1.50 to 2.00. Inner tubes usually have a gravity of less than 1.00.

Summer Session in Scientific Management

The Pennsylvania State College Bulletin for June, 1916, contains an announcement of the second summer session in factory organization, cost-accounting and scientific management conducted last year by Professor Hugo Diemer. The session will be held August 7 to 19. Professor Diemer is assisted by Mr. W. H. Tabor, who has had considerable experience in scientific management along the lines followed by the late Frederick W. Taylor.

The 1915 session resulted in the establishment of interesting acquaintanceships and the interchange of much valuable information. The age of those attending ranged from twenty-five to over sixty years, and while there were only eleven men who attended the session the interest shown makes it probable that this year the limited number of thirty will take the course.

The list of subjects includes a very wide variety under two main headings, viz.: "industrial organization" and "scientific management." Shop work in a variety of subjects relating to the work, is included in the two weeks' curriculum.

The Chamber of Mines and Oil of Los Angeles, Cal., held its annual meeting and dinner at the Jonathan Club on Tuesday, May 2. Addresses were made by Seeley W. Mudd, Warren C. Kennedy and Theodore Martin, and motion pictures were shown of Cerro Azul No. 4, said to be the world's greatest oil well. The pictures were exhibited and explained by Mr. Edward L. Doheny.

Preparation of Pure Iron and Iron-Carbon Alloys.—The Bureau of Standards has recently issued a bulletin (Scientific Paper 266) describing the preparation of iron and a series of iron-carbon alloys of a high degree of purity to be used in the study of the iron-carbon equilibrium diagram.

The Effect of Vacuum Fusion Upon the Magnetic Properties of Pure Open Hearth Iron

BY TRYGVE D. YENSEN
Research Assistant Professor, University of Illinois.

In a number of articles[1] during the last two years the writer has described the remarkable magnetic properties obtained by melting electrolytically refined iron *in vacuo*. It has been shown that it is possible by this process to obtain magnetic permeabilities ($u = B/H$) as high as 50,000, accompanied by hysteresis losses of 1/5 to 1/8 that of the best commercial transformer steels in use at the present time. The question has naturally arisen: What effect will the vacuum treatment have upon commercial grades of iron? In order to answer this question one of the purest grades of commercial iron obtainable was selected for an investigation. The composition of this iron which was made by the open hearth process according to the most approved method is as follows[2]:

S	0.025 per cent
P	0.005 per cent
C	0.010 per cent
Mn	0.025 per cent
Si	0.005 per cent
Cu	0.050 per cent
O	0.035 per cent
N	0.004 per cent
H	0.001 per cent
Fe (by diff.)	99.84 per cent
	100.00 per ent

Test pieces were prepared from this iron as it was received from the manufacturer, and others were prepared from the iron after being remelted in vacuo. The test pieces consist of rods, 1 cm. x 36 cm., used in connection with Burrows' compensated double bar and yoke method, and of rings, 4.2 cm. outside diameter x 3.8 cm. inside diameter, tested by the ordinary ballistic method. These test pieces before the final testing were annealed at 1100 deg. C. in vacuo and cooled at the rate of 30 deg. C. per hour to room temperature.

The results obtained are given in the accompanying table and in Fig. 1. It is seen that the vacuum treatment has increased the maximum permeability from two to three times and decreased the hysteresis loss by a corresponding amount.[3] For the sake of comparison there have been included in the table the results previously obtained with electrolytic iron—with and without additions of silicon—melted in vacuo. This comparison shows plainly that *nearly* as good results are obtainable using pure open-hearth iron as a base as with the pure electrolytic iron.

As far as the chemical analysis is concerned it is difficult to point out any material difference between the open-hearth iron before and after the vacuum treatment. Only as far as the CO and CO_2 gases are concerned it may be stated that there has been a material reduction by the vacuum treatment. In order to obtain further information regarding possible differences, samples were examined for density and under the microscope. The density tests showed very slight differences between the treated and untreated iron, but out of a number of tests under different conditions and by dif-

[1] Bulletins No.'s 72, 77 and 83, Eng. Exp. Sta., Univ. of Ill. Transact. A. I. E. E., 1914, Vol. 33, part 1, p. 451. Proc. A. I. E. E., Oct., 1915, p. 2455. Proc. A. I. M. E., Feb., 1916, p. 483.

[2] These figures have been supplied by the manufacturer and are said to be representative of the iron. Analyses made by the Chemistry Department of the University of Illinois check these figures satisfactorily.

[3] A similar improvement has been obtained with Swedish charcoal iron. See Bull. No. 72, Eng. Exp. Sta., Univ. of Ill., pp. 28 and 33.

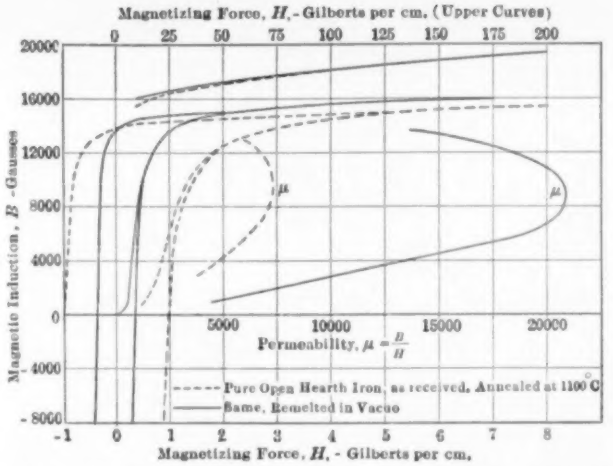


FIG. 1—MAGNETIC TEST CURVES OF PURE OPEN-HEARTH IRON AS RECEIVED AND REMELTED IN VACUO

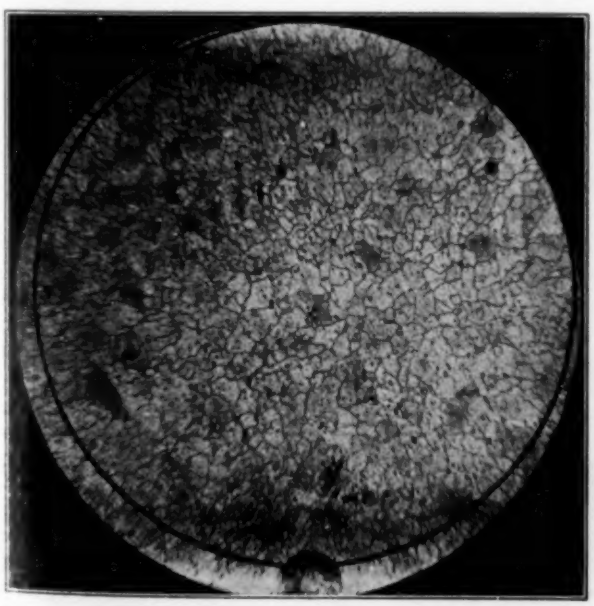


FIG. 2a—60 DIAM.—PURE IRON MADE IN OPEN-HEARTH FURNACE

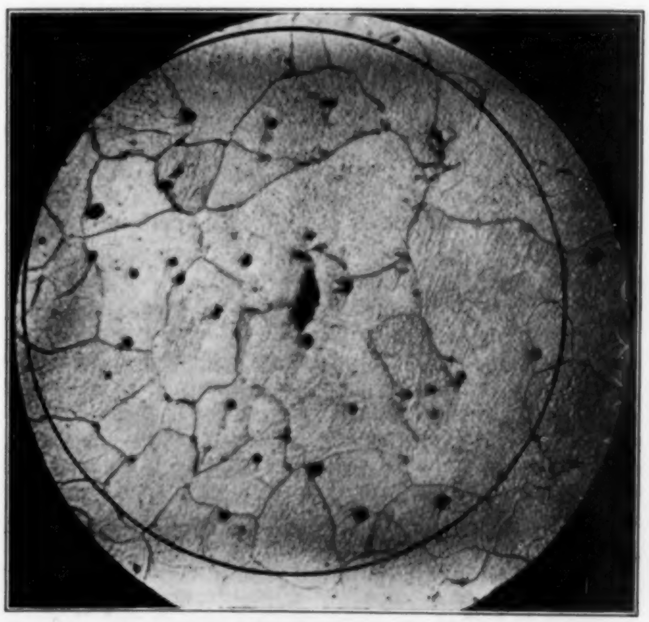


FIG. 2b—360 DIAM.—PURE IRON MADE IN OPEN-HEARTH FURNACE

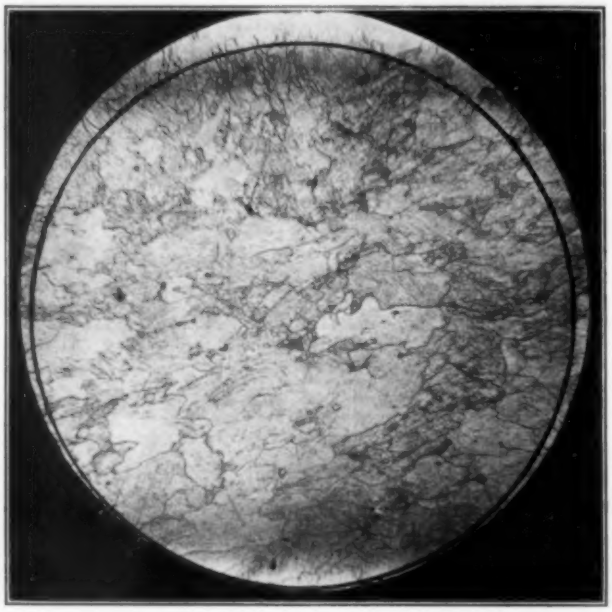


FIG. 3a—60 DIAM.—OPEN-HEARTH IRON REMELTED IN VACUO

FIG. 3b—360 DIAM.—OPEN-HEARTH IRON REMELTED IN VACUO

ferent persons the density of the vacuum-treated iron was in every case found to be higher, the average difference being about 0.1 per cent.

Figs. 2 and 3 show the photomicrographs obtained for the two samples examined. In Figs. 2a and 2b it is seen that in the untreated iron, while it is remarkably free from slag or other impurities such as are generally met with in commercial iron, there appear a large number of minute spots, evidently cavities caused by dispelled gases. The vacuum-treated iron is practically free from such cavities as seen by Figs. 3a and 3b. Furthermore, the crystals of the treated iron are much larger than those of the untreated iron.

The results thus far obtained seem to indicate that the purer the iron the larger are the crystals. Previous results also point towards a possible connection between high magnetic permeability and large crystals when comparing irons of the same general composition having received the same mechanical and heat treatment. It may be a question, however, whether magnetic permeability has anything to do with the crystal size, as it may depend solely upon the purity of the iron. In favor of this contention may be cited the fact that when pure iron has been annealed at temperatures above 900 deg. C., followed by slow cooling, the resulting crystals are much smaller than after annealing at or below 900 deg., and yet the magnetic permeability is generally increased by annealing at the higher temperatures.

From these facts and indications the only safe conclusion that may be drawn is that the open-hearth iron has been purified by the vacuum treatment to a degree not obtainable by any ordinary process of manufacture, and, furthermore, that this purification has resulted in marked improvements in the magnetic properties. Together with the results previously obtained with Swedish charcoal irons (compare footnote 3), these results show definitely that it is possible to obtain magnetic properties with commercial grades of iron by vacuum fusion that are comparable with those obtainable with electrolytic iron.

TABLE I—A COMPARISON BETWEEN THE MAGNETIC PROPERTIES OF OPEN HEARTH IRON BEFORE AND AFTER BEING REMELTED IN VACUO. ALSO COMPARED WITH ELECTROLYTIC IRON

Specimen No.	Kind of Specimen	Max. Perm.	Density for Maximum Permeability	Permeability		Hysteresis Loss, Ergs per Cub. Cm. per Cycle		Retentivity in Gausses		Coercive Force in Gilberts per Cm.		Spec. Elec. Resist., Microhms
				B = 10,000	B = 15,000	B = 10,000	B = 15,000	B = 10,000	B = 15,000	B = 10,000	B = 15,000	
OPEN HEARTH IRON, AS PURCHASED Machined From ½-Inch Rod. Annealed at 1100 Deg. C.												
1.AR	Rod	7,250	10,000	7,250	2710	....	5550	9000	13,000	.85	1.0	10.15
OPEN HEARTH IRON REMELTED IN VACUO, ANNEALED AT 1100 DEG. C.												
2.4-01	Ring	14,300	8,500	13,700	5700	986	2063	8400	12,300	.33	.39	
4-01	Rod	14,180	8,500	13,200	5350	1060	2190	8700	12,300	.37	.40	10.05
4-02	Ring	16,500	9,500	16,450	6400	935	2010	8700	13,900	.30	.35	
4-03	Ring	17,000	9,000	16,700	8250	852	1755	8400	12,600	.28	.33	
4-03	Rod	20,900	9,000	20,200	7500	865	1760	9300	13,600	.30	.34	10.20
4-04	Ring	16,300	10,000	16,300	6000	870	1880	8400	13,300	.30	.35	
ELECTROLYTIC IRON MELTED IN VACUO, ANNEALED AT 1100 DEG. C.												
3.3-54	Rod	22,800	8,000	21,300	1365	665	1860	9300	13,300	.20	.24	9.84
3-55	Rod	25,800	9,000	25,600	1365	707	1451	9300	12,700	.23	.28	9.85
ELECTROLYTIC IRON WITH 0.15 PER CENT Si MELTED IN VACUO, ANNEALED AT 1100 DEG. C.												
4.3Si06	Rod	66,500	6,500	41,700	6000	286	916	9080	12,000	.09	.165	11.80
ELECTROLYTIC IRON WITH 3.0 PER CENT Si MELTED IN VACUO, ANNEALED AT 1100 DEG. C.												
5.3Si40	Ring	36,200	8,000	31,300	790	337	757	7700	11,000	.09	.10	
3Si40	Rod	72,600	9,000	69,500	2500	254	926	9400	13,700	.09	.16	44.75

Industrial Index.—A cumulative index of the industrial arts, made from about 80 trade and engineering journals is issued in April, June, October and December by the H. W. Wilson Co., White Plains, N. Y. The December number contains the annual cumulation.

Newark to Hold Industrial Exposition.—In conjunction with the big celebration of its 250th anniversary, which commenced May 1 and will last to Oct. 1, Newark, N. J., will conduct an industrial exposition at the First Regiment Armory in that city May 13 to June 3. Over 133 lines of industry will be represented in about twice that number of exhibits. Newark is the center of large and varied manufacturing industries, and the exposition will be officially opened by Secretary of War Baker on Saturday, May 13.

Electrolysis of Alkaline Solutions of Potassium Sulphocyanate

BY WELTON J. CROOK,* L. E. BOOTH AND ARTHUR THIEL

Sulphocyanates are invariably present in the cyanide solutions resulting from the cyanidation of ores containing sulphides, more particularly ores containing the sulpho-salts of silver, since the dissolution of the silver from such ores involves the breaking up of the sulpho-compound to the extent that silver is dissolved, with the consequent formation of sulphocyanate. The alkaline sulphocyanates are very stable and, in general, are not solvents for the precious metals. Due to their stability, cyanide available for dissolution is not regenerated from them at any stage of the process unless electrolytic precipitation be used.

The first investigation upon the effect of electrolysis upon the alkaline cyanates under plant conditions was done by Clevenger and Hamilton[1] at Minas Prietas, Mexico, in 1907. An account of this work was never published, but it, together with work done later at Virginia City, Nev., by Clevenger, covered practically the same ground as that which has been later recorded by Clennell.

The purpose of the authors in making the investigation, of which this paper gives an account, was to study the reactions taking place during the electrolysis of aqueous solutions of the alkaline sulphocyanates in more detail than had been previously done. In 1911 Clennell[2] investigated, in a rough way, the effect produced by electrolyzing an aqueous solution of potassium sulphocyanate. He did not record the voltages used in either of his series of electrolyses, but stated that he used in his second series a current density of from 20 to 35 amp. per square foot of anode surface.

The results of Clennell's work are shown in Table I. The solution used in the first series consisted of: water, 60 lb.; commercial potassium sulphocyanate, 3 lb.; lime, 350 grams. This would approximate a 5-per cent solution. The solution was agitated by paddles and electrolyzed with hard carbon electrodes having an effective area of 1/7 sq. ft.

TABLE I.

Time Test	Free KCN, Per Cent	Total KCN, Per Cent	Alkali, NaOH, Per Cent
Before applying current	0.0025	.....	0.210
After electrolyzing 1 hour	0.008	0.0115	0.202
After electrolyzing 24 hours	0.105	0.107	0.173
After electrolyzing 48 hours	0.117	0.118	0.098
After electrolyzing 72* hours	0.132	0.133	0.060

*Fresh lime added—50 grams.

Clennell states that potassium sulphocyanate is decomposed by electrolysis, in the presence of an alkali, as shown by the following equation:

$$KCNS + O_3 + Ca(OH)_2 = KCN + CaSO_4 + H_2O.$$

Investigation of Methods of Analysis

The most difficult part of the investigation proved to be the finding of reliable methods for analysis of the electrolyzed solution. It was thought that the chemical compounds which would be formed in the electrolyzed solution would be: (*a*) potassium sulphocyanate (KCNS); (*b*) potassium cyanate (KCNO); (*c*) potassium sulphate (K_2SO_4); (*d*) potassium hydroxide (KOH); (*e*) sulphur dioxide (SO_2); (*f*) potassium sulphite (K_2SO_3); (*g*) potassium cyanide (KCN); (*h*) carbon dioxide (CO_2). Methods for the determination of these compounds in the presence of each other were accordingly investigated.

METHOD FOR CYANATE (CNO)

1. The methods of Paterno and Pannain,[3] which are given below, were first investigated:

1. To a 10-c.c. sample add a known excess of standard silver nitrate solution. Dilute to 100 c.c. and filter. In 50 c.c. of the filtrate determine the excess silver nitrate by Volhard's method. The $AgNO_3$ added, minus that found in the filtrate, gives the amount consumed by the cyanide, cyanate, carbonate and hydroxide, or anything else precipitated by $AgNO_3$ in neutral solution.

2. To a second 10-c.c. sample add a known excess of $AgNO_3$ and an excess of acetic acid. Dilute to 100 c.c. and filter. In 50 c.c. of the filtrate determine the excess $AgNO_3$ as above. The difference between the amounts of $AgNO_3$ used in each case is consumed by the precipitation of AgCN and AgCNO.

3. To a third 10-c.c. sample add a known excess of silver nitrate and an excess of dilute nitric acid. Dilute to 100 c.c.. In 50 c.c. of the filtrate determine the excess $AgNO_3$ as above. The difference between the $AgNO_3$ consumed in each case is used in the precipitation of KCN. The $AgNO_3$ consumed in (2) minus that consumed in (3) is the amount of $AgNO_3$ used in precipitating AgCNO.

In order to test the accuracy of this method when used with dilute solutions, a series of experiments was conducted, using a solution containing 0.001 gram of KCNO per cubic centimeter. This solution was made up by weight from Merck's C. P. potassium cyanate.

Series 1.—10 c.c. of KCNO solution were taken in each case, and amounts of $AgNO_3$, varying from 5 to 40 c.c., were added. The neutral solution was diluted to 100 c.c. and filtered. Fifty cubic centimeters of the filtrate were then titrated with standard KCNS solution, using ferric alum indicator.

TABLE II.

	cc. KCNO Sol Taken	cc. $AgNO_3$ Added	cc. Acetic Acid (1-1)	cc. KCNS Required	Grams KCNO Present	Grams KCNO Found	Per Cent Indicated
Series 1	10	5	None	2.0	0.01	0.006449	64.49
	10	5	None	2.2	0.01	0.008408	84.08
	10	10	None	6.1	0.01	0.008945	89.45
	10	10	None	6.6	0.01	0.009249	92.49
	10	15	None	10.9	0.01	0.0104324	104.32
	10	20	None	15.6	0.01	0.010383	103.83
	10	25	None	20.1	0.01	0.010926	109.26
	10	30	None	24.7	0.01	0.011185	111.85
	10	40	None	33.6	0.01	0.010821	108.21
Series 2	10	5	None	1.9	0.01	0.009457	94.57
	10	10	None	6.3	0.01	0.010241	102.41
	10	20	None	10.7	0.01	0.011214	112.14
	10	25	None	15.1	0.01	0.012108	121.08
	10	30	None	23.8	0.01	0.014185	141.85
	10	40	None	32.9	0.01	0.014910	149.10
Series 3	10	5	5	3.8	0.01	0.005811	58.11
	10	10	5	7.8	0.01	0.005123	51.23
	10	10	5	7.6	0.01	0.005811	58.11
	10	10	10	8.6	0.01	0.002368	23.68

Series 2.—Same as Series 1, except that the solution was diluted to 50 c.c. before filtering and 25 c.c. were titrated.

Series 3.—Same as Series 1, except that 5 c.c. to 10 c.c. of acetic acid were added.

The results given in Table II indicate that this method is unreliable for dilute solutions. Increasing the amount of $AgNO_3$ added raises the KCNO indicated. The addition of acetic acid gives results 50 per cent low. It will be noted that dilution is also an important factor.

Attention was then turned to the method of Cumming and Mason[4] for cyanate, which is based upon the

*Professor of Metallurgy, South Dakota State School of Mines.
[1]Personal communication—G. H. Clevenger.
[2]Clennell. *Eng. & Min. Jour.*, May 27, 1911.
[3]*Gazette Chemica Italiana* 34 (2) 152.
[4]Proc. of Soc. of Chem. Ind. of Victoria. July-Aug., 1903. Also Chem. News, Jan. 5, 1906.

neutralization of a standard solution of sulphuric acid according to the following equation:

$$2\ KCNO + 2\ H_2SO_4 + 2\ H_2O = K_2SO_4 + (NH_4)_2SO_4 + 2\ CO_2.$$

This method, as given by Clennell,[5] is as follows:

"This method depends on the facts (*a*) that cyanates are neutral to methyl orange; (*b*) that, when boiled for a short time with a mineral acid, they are quantitatively converted to CO_2 (which escapes), ammonium salts and salts of the metal originally present in the cyanate remaining in solution. A known volume of the solution (which may contain carbonate as well as cyanide and cyanate) is first titrated in the cold with standard acid, using methyl orange or Congo red as an indicator. The quantity of acid to effect a change in a neutral solution of the indicator should be determined, and the proper correction applied in making the test. Having noted the point where the solution becomes neutral, a sufficient measured excess of standard acid is added beyond this point. The mixture is then boiled a few minutes to insure complete decomposition of the cyanate and expulsion of the CO_2. The boiling may be stopped when bumping sets in. The solution is then cooled, and more indicator added if necessary. The residual excess of acid is now determined by titrating back with standard alkali. The difference between the excess acid added beyond the neutral point and the residual acid is the equivalent of the cyanate, according to the equation previously given."

In order to test the accuracy of the method, a solution of KCNO containing 4.01 grams per liter was made up. Both phenolphthalein and methyl orange were used as indicators. The results are given in Tables III and IV.

TABLE III.—USING PHENOLPHTHALEIN

cc. KCNO Sol. Taken	cc. N/10 H_2SO_4 Added	cc. KOH Required	Per Cent KCNO Indicated
10	10	1.5	85.94
10	10	1.2	88.90
10	10	1.5	85.94
10	10	1.9	80.01
10	15	6.8	82.91

TABLE IV.—USING METHYL ORANGE

cc. KCNO Sol. Taken	cc. H_2SO_4 Added	cc. KOH Required	Per Cent KCNO Indicated
10	10	0.8	92.9
10	15	6.0	91.00
10	15	5.9	92.15

The low and erratic results obtained when using phenolphthalein were undoubtedly due to the fact that this indicator will not give satisfactory results in the presence of ammonia.[6]

Encouraged by the results obtained in the preceding series, when methyl orange was used as an indicator, a further series was run. A solution containing 1 gram KCNO per liter was made up for this series, methyl orange being used as an indicator in making the titrations. (Table V.)

TABLE V.

cc. KCNO Sol. Taken	cc. H_2SO_4 Added	cc. KOH Required	Per Cent KCNO Indicated
40	10	0.75	93.75
40	20	10.8	93.25

The value of the N/10 H_2SO_4 in terms of KCNO and CNO was calculated from the below equation:

$$2\ KCNO + 2\ H_2SO_4 + 2\ H_2O = K_2SO_4 + (NH_4)_2SO_4 + 2\ CO_2.$$

The value of N/10 H_2SO_4 in terms of KCNO per cubic centimeter was found to be 0.004055 gram, and in terms of CNO to be 0.00210 gram.

As a further test of this method, a stronger solution of KCNO, containing 5 grams KCNO per liter, was made up. It was found, however, that, with a solution of this strength, a blue coloration was formed when the N/10 acid was added and the solution boiled. The same result was obtained in all of many trials. At the time it was thought that, due to accident, some iron salt might be present in the solution but, after special precautions were taken and all reagents tested for iron, the same effect persisted. It is thought that the coloration is due to some complex cyanogen compound.

The method is apparently not applicable to any but weak solutions, as the blue coloration renders the titration with methyl orange impossible.

This method was adopted for the determination of cyanate in the weak solutions resulting form electrolysis. The N/10 H_2SO_4 solution employed in making the titrations was checked by the $BaSO_4$ method.[7]

METHOD FOR SULPHOCYANATE (CNS)

The first method tried for the determination of sulphocyanate (CNS) was a reversal of the well known iodate method[8] for copper. Twenty cubic centimeters of the sulphocyanate solution were made just acid with HCl, then 4 c.c. of acid were added in excess. The solution was heated almost to boiling and 15 c.c. of copper sulphate solution and 15 c.c. of sodium bisulphite solution added and stirred well. The solution was then filtered through a close filter paper and washed rapidly with boiling water. The copper present in the precipitate was then determined by titrating with a standard solution of potassium iodate (KIO_3) using chloroform as an indicator. The percentage of sulphocyanate present was then computed. The copper sulphate solution used contained 64 grams of the hydrated salt per liter and the sodium bisulphite ($NaHSO_3$) solution contained 75 grams per liter.

This method with solutions of known sulphocyanate content gave accurate results when carefully done. However, it requires considerable time. As an improvement upon the above method, direct titration of the sulphocyanate with potassium iodate was tried. The method consisted in taking a 20-c.c. sample of the solution in a 250-c.c. flask, together with 30 c.c. of concentrated HCl and 5 c.c. of chloroform. It was then titrated direct with the KIO_3 solution.

The solution of potassium iodate was standardized by means of C.P. copper foil. One c.c. was found to be equal to 0.00185 gram sulphocyanate.

In order to test this method a solution of potassium sulphocyanate (KCNS) was prepared of such a strength that 20 c.c. contained 0.0242 gram CNS. The solution from which the samples were taken contained the same substances as the electrolyte, among others SO_2 in the form of Na_2SO_3. (Table VI.)

TABLE VI.

	Grams CNS Present	Grams CNS Found	Per Cent Indicated
1	0.02420	0.02451	101.2
2	0.02420	0.02484	102.5
3	0.02420	0.02462	101.7

It will be noted that the results were all high. This was probably due to the presence of SO_2, which reacted with the standard iodate solution according to the below equation:

$$4\ Na_2SO_3 + 2\ KIO_3 + 4\ HCl = 4\ Na_2SO_4 + 2\ KCl + 2\ ICl + 2\ H_2O.$$

The equation for the titration of CNS by KIO_3 is given below:

$$4\ KCNS + 6\ KIO_3 + 8\ HCl = 4\ HCN + 2\ KCl + 6\ ICl + K_2SO_4 + 2\ H_2O.$$

[5]Chemistry of Cyanide Solns. P. 183.
[6]Analytical Chemistry. Treadwell & Hall. Vol. II, p. 434.
[7]Treadwell and Hall Analytical Chem. Vol. 2, pp. 268-270.
[8]The Iodate Method for Cu. W. W. Brostrom, E. & M. J., Aug. 1, 1914. Also *Jour. Am. Chem. Soc.*, Vol. 30, p. 760.

The sample of KCNS solution contained 0.002044 gram SO_2 in each 20 c.c. sample. Hence $0.002044 \div 0.00715 = 0.28$ c.c. of standard KIO_3 which should be subtracted from the amount used in the titration of 20 c.c. of the KCNS solution for CNS.

After making this correction for the presence of SO_2, the results were as given in Table VII.

TABLE VII

	Gm. CNS Present	Cc. KIO_3 Used	Gm. CNS Found	Per Cent Indicated
1........	0.02420	11.05	0.02386	98.6
2........	0.02420	11.2	0.02419	99.9
3........	0.02420	11.1	0.02391	99.0

When this correction was applied this method checked within reasonable limits and it was, therefore, used in the analysis of the electrolyte produced by the several series of electrolyses.

METHOD FOR SO_4

The first method tried consisted in adding an excess of a solution of silver nitrate to a 50 c.c. sample of the electrolyte in order to precipitate CNS as AgCNS which was filtered out. The excess of silver was precipitated with HCl and also filtered out. The SO_4 was then precipitated in the usual way with $BaCl_2$[9].

It was later found that KCNS does not interfere with the precipitation of $BaCl_2$. When KCNS is boiled with HCl the following reaction probably takes place:

$$3\ KCNS + 6\ HCl + 6\ H_2O =$$
$$3\ KCl + 3\ NH_4Cl + 3\ H_2S + 3\ CO_2.$$

If a filter paper moistened with lead acetate is held over a beaker containing boiling KCNS solution acidified with Hcl, the paper will be darkened in a manner characteristic of the action of H_2S on lead acetate. Taking these various facts into consideration, the method was modified as follows: A 20 c.c. sample of the electrolyte was made acid with 1 c.c. HCl, and boiled. The SO_4 was then precipitated with $BaCl_2$ as before. Using 20 c.c. samples of the electrolyte containing 0.00384 gram SO_4, the results of Table VIII were obtained.

TABLE VIII

Cc. Sample Taken	SO_4 Present	Wt. $BaSO_4$	SO_4 Found	Per Cent Indicated
20	0.00384	0.0094	0.00386	100.5
20	0.00384	0.0093	0.00382	99.5

This method was, therefore, used in all subsequent determinations.

METHOD FOR SO_2.

Considerable difficulty was met in finding a suitable method for the determination of the sulphite in the electrolyte. The first method tried was to treat the sample with an excess of bromine water and remove the excess by boiling. The sulphur was then precipitated with $BaCl_2$ and weighed in the usual way. From the weight of $BaSO_4$ obtained, the weight of the $BaSO_4$ found in the determination of SO_4 was subtracted and the remainder calculated to SO_2. This method was found to be unsatisfactory and a method depending upon the oxidation of the sulphur in the KCNS by means of iodine was accordingly investigated.

A 20 c.c. sample of a solution containing 0.00204 gram SO_2 in the presence of KCNS was made acid with three c.c. of concentrated HCl and 10 c.c. of iodine solution added. The solution was boiled until colorless and precipitated with $BaCl_2$ solution. The precipitate of $BaSO_4$ formed should have contained the total sulphur in the solution. The weight of $BaSO_4$ obtained from the SO_4 determination was substracted and the remainder calculated to SO_2. In order to determine the accuracy of the method a series of analysis were run upon solutions of known SO_2 content, but the results obtained were all found to be decidedly low. It was thought that perhaps the amount of iodine and HCl added were insufficient to decompose and oxidize the KCNS completely. Iodine was therefore replaced by bromine but low results were still obtained.

Another method, involving the removal of CNS by precipitation as CuCNS by boiling with CuCl solution[10], was tried. It was found that, after the CuCNS had been filtered out and iodine solution added, a white precipitate came down, making precipitation with $BaCl_2$ impossible. The method was, therefore, discarded as being impractical.

The method finally adopted proved to be extremely simple and effective. It depended on the oxidation of the KCNS by means of potassium iodate (KIO_3) solution according to the following equation:

$$4\ KCNS + 6\ KIO_3 + 8\ HCl =$$
$$2\ KCl + 4\ K_2SO_4 + 6\ ICl + 4\ HCN + 2\ H_2O.$$

The method is as follows: To a 20 c.c. sample, 40 c.c. of KIO_3[11] solution were added, together with 1 c.c. of concentrated HCl. The solution was then boiled and the sulphur present precipitated with $BaCl_2$. From the weight of $BaSO_4$ obtained the weight of the $BaSO_4$ corresponding to the KCNS present was subtracted and the remainder calculated to SO_2.

Results obtained by the method were as given in Table IX.

	Grams $BaSO_4$ Obtained	Grams $BaSO_4$ Due to KCNS	$BaSO_4$ from SO_2 Grams	SO_2 Present Grams	SO_2 Indicated Grams
1........	0.1144	0.1068	0.0076	0.00204	0.00208
2........	0.1143	0.1068	0.0075	0.00204	0.00205

This method was used in subsequent analyses.

METHOD FOR KCN

The first method tried was as follows: To the sample was added a known excess of silver nitrate and 10 c.c. of HNO_3 (1-1). The volume was made up to 100 c.c. and the excess silver nitrate titrated with standard NH_4CNS, using a 50 c.c. sample. The amount of silver nitrate consumed by the (CN) and (CNS) was thus obtained. From this the amount previously determined to have been consumed by the (CNS) was subtracted, leaving the amount of silver nitrate consumed by the (CN). From this the weight of (CN) present was calculated.

This method, which theoretically should give good results, proved to be unsatisfactory. Results obtained with it were either very high or very low.

According to Clennell[12], (CN) may be titrated direct with silver nitrate in the presence of alkalies, ferrocyanides and thiocyanates and fairly accurate results obtained. The presence of KCNS and KCNO interferes but slightly unless over 1 per cent of these substances be present. In testing this method a series of 20 c.c. samples, each containing 0.00193 gram (CN), were titrated. The standard silver nitrate used was prepared by dissolving 6.525 grams of C.P. crystalized $AgNO_3$ in 1 liter of water.

The results obtained by direct titration were as given in Table X.

TABLE X

Cc. Sample	Cc. $AgNO_3$ Used	Grams CN Present	Grams CN Indicated
20	0.9	0.00193	0.00172
20	1.0	0.00193	0.00191
20	1.1	0.00193	0.00210
20	1.0	0.00193	0.00191
20	1.2	0.00193	0.00229
20	1.0	0.00193	0.00191
		Average	0.00197

[9] Low. Technical Methods of Ore Analysis. p. 258.

[10] $CuCl_2$ solution was reduced to CuCl by means of stannous chloride.

[11] KIO_3 solution contained 40 grams KIO_3 per liter.

[12] Clennell. Chemistry of Cyanide Solutions. p. 4.

The method of direct titration does not appear to give absolutely accurate results but the errors shown were not sufficiently large to appreciably affect the results of this investigation. This method was, therefore, adopted for subsequent analyses.

METHOD FOR (OH)

Much difficulty was experienced in finding a suitable method for determining the (OH) present. The first method tried consisted in precipitating the carbonate in a 20 c.c. sample by the addition of an excess of $Ba(NO_3)_2$, diluting to 100 c.c. and allowing to stand, tightly corked, for an hour. The solution was then filtered and to 25 c.c. of the filtrate a known excess of silver nitrate was added and the volume made up to 100 c.c., filtered and the excess silver nitrate determined. From the amount of $AgNO_3$ consumed was subtracted the equivalent of the (CN), (CNO) and (CNS) previously determined. The remainder was calculated to hydroxide. The results obtained by this method could not be made to check. All the methods available for the determination of (OH) were tried out with varying degrees of success. It was finally decided to determine alkalinity instead of (OH), after the manner in which the "protective alkalinity" of working cyanide solutions is determined. 20 c.c. samples were accordingly taken and titrated for (CN) by Leibig's [13] method with $AgNO_3$ to the first turbidity. Two drops of phenolphthalein were then added and the solution titrated to the colorless end point with N/10 H_2SO_4. When a 20 c.c. sample of the solution is taken each c.c. of N/10 H_2SO_4 = 0.0280 per cent KOH. The alkalinity was recorded in terms of percentage of KOH.

METHOD FOR CO_2

The first method tried consisted in adding an excess of $Ca(NO_3)_2$ to a 50 c.c. sample of the solution which was allowed to stand in a stoppered flask for one-half hour. It was then filtered and the precipitate washed with hot water. The CO_2 in the precipitate was then determined by an alkalimeter[14]. According to Treadwell and Hall[15], this method affords excellent results when large quantities of CO_2 are involved but with small amounts, such as were present in this case, the method was found to be inaccurate on account of the weight of the apparatus. Results obtained by this method were unsatisfactory and it has the further disadvantage of being somewhat tedious.

The following method was then tried. The CO_2 was precipitated with $BaCl_2$ and the resulting $Ba(CO_3)_2$ filtered out, washed and titrated with an excess of N/10 H_2SO_4. The excess of H_2SO_4 was determined by titrating back with standard alkali solution. The method gives slightly high results, as may be seen by the following results, but the results were found to be sufficiently accurate to warrant its adoption. (Table XI.)

TABLE XI

Cc. H_2SO_4 Used	Grams CO_2 Present	Grams CO_2 Indicated
5.2	0.0111	0.0114
5.4	0.0111	0.0118
5.3	0.0111	0.0116
5.6	0.0111	0.0123

In order to test the accuracy of the various analytical methods selected, a solution was prepared containing all of the compounds which would probably be found in the solution after electrolysis. The methods of analysis previously described were used for making the various analyses upon this solution, a 20 c.c. sample being taken for each determination. (Table XII.)

TABLE XII.

Compound	Grams Present	Grams Found	Percentage Indicated
CNS	0.02420	0.02401	99.1
CNO	0.01690	0.01660	97.2
CN	0.00190	0.01970	102.0
SO_4	0.00380	0.00380	100.0
SO_2	0.00200	0.00205	100.9
*CO_2	0.01110	0.00117	105.4

Results of Electrolyses of Alkaline Solutions of KCNS:

The electrolyzing cell used throughout this investigation was a rectangular glass jar, 7 in. x 7 in. x 10 in., having a capacity of 7 liters. The electrodes used were two graphite plates 11 in. x 2¾ in. The distance between the electrodes varied from 3½ in. to 4 in. The submerged portion of the electrodes measured 7½ in. x 2¾ in. The solution electrolyzed contained approximately 60 grams of potassium sulphocyanate (Merck) per liter. The exact percentage, as well as the voltage and current in amperes, is shown in Tables 13 to 17, giving the results.

TABLE XIII.—ELECTROLYSIS NO. 1.

Voltage 2.7. Current 0.5 ampere. No alkali added.

Time	Per Cent CNS	Per Cent CN	Per Cent SO_4	Per Cent OH	Per Cent CNO	Per Cent CO_2	Per Cent SO_2
Original solution	0.601	None	None	None	0.022	None	None
End of 1 hr.	0.595	None	0.004	None	0.022	None	None
End of 2 hrs.	0.593	None	0.006	None	0.021	None	None
End of 3 hrs.	0.590	None	0.008	None	0.021	None	None
End of 4 hrs.	0.585	None	0.011	None	0.020	None	None
End of 5 hrs.	0.581	None	0.015	None	0.020	None	None

The solution at the end gave an acid reaction. It is seen that under this condition the CNS is broken up and forms sulphate, but no regeneration of (CN) takes place.

TABLE XIV.—ELECTROLYSIS NO. 2.

Voltage 2.7 volts. Current 0.5 ampere. Alkali added.

Time	Per Cent CNS	Per Cent CN	Per Cent SO_4	Per Cent OH	Per Cent CNO	Per Cent CO_2	Per Cent SO_2
Original solution	0.540	None	None	0.560	0.019	0.014	None
After 1 hr.	0.537	0.003	0.003	0.360	0.021	0.016	None
After 2 hrs.	0.534	0.003	0.003	0.358	0.020	0.014	None
After 3 hrs.	0.533	0.003	0.008	0.353	0.020	0.018	None
After 4 hrs.	0,532	0.003	0.010	0.353	0.020	0.014	None

This electrolysis was run under the same conditions as No. 1 and was intended to show the effect of having the solution alkaline. In this case there is a small amount of (CN) formed, accompanied with a slight decrease in alkalinity.

TABLE XV.—ELECTROLYSIS NO. 3.

Voltage 5.4. Current 1.8 amperes. Alkali added.

Time	Per Cent CNS	Per Cent CN	Per Cent SO_4	Per Cent OH	Per Cent CNO	Per Cent CO_2	Per Cent SO_2
Original solution	0.485	None	None	0.280	0.005	0.008	None
After 1 hr.	0.481	0.005	0.025	0.262	0.006	0.005	None
After 2 hrs.	0.470	0.011	0.045	0.246	0.005	0.005	None
After 3 hrs.	0.457	0.013	0.057	0.230	0.005	0.005	None
After 4 hrs.	0.441	0.016	0.067	0.207	0.006	0.005	None
After 5 hrs.	0.438	0.019	0.084	0.190	0.007	0.006	None

It will be noted that, with the increase in voltage, the formation of (CN) is much greater than in Electrolysis No. 2. The formation of SO_4 is also largely increased. The CNO and CO_2 remain almost stationary.

TABLE XVI.—ELECTROLYSIS NO. 4.

Voltage 7.0. Current 3.05 amperes. Alkali added.

Time	Per Cent CNS	Per Cent CN	Per Cent SO_4	Per Cent OH	Per Cent CNO	Per Cent CO_2	Per Cent SO_2
Original solution	0.441	None	None	0.400	0.007	0.018	None
After 1 hr.	0.414	0.008	0.031	0.384	0.006	0.020	None
After 2 hrs.	0.410	0.016	0.053	0.361	0.009	0.020	None
After 3 hrs.	0.394	0.021	0.083	0.330	0.010	0.016	None
After 4 hrs.	0.365	0.023	0.120	0.300	0.008	0.022	None
After 5 hrs.	0.360	0.027	0.151	0.266	0.008	0.018	None

It will be noted that, with the higher voltage, the increase in CN is proportional to the decrease in CNS and KOH. The CNO and CO_2 remain stationary, as in electrolysis No. 3.

*The method used in this determination, and in subsequent determinations, is a slight modification of the one previously given. It is as follows: In a 20 cc. sample the carbonate present was precipitated with $Ca(NO_3)_2$ and the filtrate made neutral. A known excess of N/10 H_2SO_4 was added and the solution boiled. The excess acid was then titrated back with N/10 alkali, using phenolphthalein as indicator.

[13] Clennell. Chemistry of Cyanide Solutions. p. 4.
[14] Analytical Chemistry. Treadwell and Hall, vol. 2, pp. 293-295.
[15] Analytical Chemistry. Treadwell and Hall, vol. 2, p. 295.

TABLE XVII.—ELECTROLYSIS NO. 5.

Voltage 8.9. Current 4.0 amperes. Alkali added.

Time	Per Cent CNS	Per Cent CN	Per Cent SO_4	Per Cent OH	Per Cent CNO	Per Cent CO_2	Per Cent SO_3
Original solution..	0.494	None	None	0.361	0.007	0.008	None
After 1 hr.........	0.474	0.013	0.057	0.328	0.005	0.009	None
After 2 hrs........	0.454	0.021	0.089	0.300	0.007	0.008	None
After 3 hrs........	0.436	0.029	0.122	0.224	0.008	0.008	None
After 4 hrs........	0.416	0.036	0.158	0.174	0.008	0.007	None
After 5 hrs........	0.398	0.042	0.192	0.146	0.008	0.007	None

Conclusion

When an alkaline sulphocyanate solution is electrolyzed the decomposition products are KCN and K_2SO_4.

There is little or no KCNO, CO_2 or SO_3 formed.

Clennell's equation:

$$KCNS + O_3 + 2\ KOH = KCN + K_2SO_4 + H_2O$$

seems to hold for alkaline solutions.

When a neutral sulphocyanate solution is electrolyzed, HCN is given off as a gas and the solution becomes acid.

Acknowledgment.—We are indebted to Prof. G. H. Clevenger for suggesting the subject of this investigation and for valuable suggestions made during the course of the work.

Blast Furnace Operation

Casting and Flushing the Furnace, Blowing In, Blowing Out, and Banking

BY J. E. JOHNSON, JR.

In earlier articles the descent of the iron and slag into the hearth has been described. One of the important factors in operation and one not always easy to accomplish is their removal at the proper time and under strict control.

In the earlier furnaces no attempt was made to withdraw the slag separately from the iron, and at charcoal furnaces this practice is still followed in some cases. The cinder comes out of the iron notch at casting time and at no other time.

The introduction of coke and anthracite as furnace fuels brought about much larger slag volumes, as already described. These resulted in causing the hearth to fill up much more rapidly, and when outputs had reached a point only a fraction of what they are to-day it was found that the slag rose around the tuyeres and impeded the driving of the furnace, causing increased blast resistance and covering the slag so as to impede its circulation. This resulted in providing a separate outlet for the slag at a considerably higher level than the tapping hole for the iron, but well below the level of the tuyeres, so that by draining off the slag down to this point it would be removed from the tuyere zone and its bad effect on the operation of the furnace eliminated.

The earlier cinder notches were a sort of low doorway, a foot or two wide by 3 or 4 in. high, with a water-cooled lintel or "tymp" above it, which could only be closed with clay balls driven in with a stopping hook. This operation involved taking the blast off the furnace at each flush, because the sparks and flame blown out the opening not only made it virtually impossible for a man to work in front of it, but also blew away the clay stop as fast as it could be put in. This practice involved taking the blast off the furnace from one to four times between casts. This reduced the output, disturbed the regular action of the furnace, particularly the settling of the stock, and necessitated much work.

About forty years ago Mr. F. W. Lürman of Germany invented the water-cooled cinder notch which is now practically in universal use. By a gradual process of evolution since that time this has now developed into a water-cooled monkey, which is exactly like a tuyere in its general outline and appearance, but much smaller. This is supported and protected by a larger water-cooled bronze casting, known as the cinder cooler, which is practically identical except in size with the tuyere cooler. Frequently this in turn is protected by a still larger cooler extending back to the outer wall of the furnace, which may be either of the iron-pipe coil construction or a still larger bronze casting, generally the former.

The cinder notch, as it is called— that is, the monkey —is closed by an iron plug on the end of a long iron rod, which serves as a handle. This piece, called the "bot," acts as a plug and also as a chill. When a blubbering or sputtering of the stream of cinder indicates that the blast is blowing out above it, and therefore that its level is down to that of the notch, the furnace "keeper" takes the bot by its long handle, puts it through the cooler and up to the base of the monkey, then gives it a quick thrust and holds it for a few seconds. The cold bot and the water-cooled walls of the monkey chill the thin skin of slag between them and instantly make a perfect joint. The bot does not project through the cinder monkey, and is virtually not exposed to the heat except on its extreme end, and even that is chilled over by the cooling action of the adjacent monkey. Consequently this bot lasts quite a long time. It is generally allowed to remain in the monkey until the time for the next flush, when it is pulled out with a ring and wedge. A sharp steel bar is inserted into the hole which it left and the scull is broken through either by poking with the bar or by a couple of blows on the outer end of the latter with a sledge. By having the handle of the bot bent it can be operated by a man standing, not directly in front of the cinder notch but well to one side, and consequently to some extent out of danger from flame and shots of slag. A shield can be provided where necessary, from behind which the bot can be operated without the keeper's exposing his face to injury.

It will be seen that by this method the necessity of taking the blast off the furnace at each flush is entirely eliminated, while the labor incident to opening and shutting the slag notch is reduced to an insignificant fraction of what it was by the old method. Moreover, by the use of these water-cooled apertures the slag can be allowed to run for an indefinite time without cutting out the hole, whereas under the old system the hole gradually became enlarged by the blowing of the blast through it, so if the cinder ran too long it was difficult to stop.

Coke furnaces are now flushed from two to five times before cast and virtually without any labor. In very recent months an apparatus has been introduced at the Edgar Thomson furnaces whereby the bot is controlled by means of a cylinder operated by steam or compressed air. The bot is so held that it must enter the monkey properly without being guided by hand, and consequently the keeper can shut the slag notch from any desired distance by simply opening the valve controlling the cylinder. This eliminates absolutely the danger to the operator from shots of slag, which in time gone by have caused many slight burns and occasionally the loss of an eye.

The slag cannot be all removed by flushing, because the cinder notch must be located at a safe height above the top surface of the molten iron at its highest point, so in the case of a delay of an hour or two in casting the iron will not rise high enough to come in contact with the monkey and cinder cooler, therefore there must in normal operation be an appreciable height between the top surface of the iron and the cinder notch which must be filled with slag before any can be tapped out.

The reason for keeping the cinder notch well above the iron is that while water-cooled bronze is almost absolutely safe against the cutting action of the stream

of molten slag, it has only a slight resistance to the cutting power of a stream of molten iron, and, the cooler walls being very thin, if the iron does cut the bronze it immediately runs into the water-cooled cavity and a terrific explosion inevitably results.

The violence of these explosions, which is almost beyond belief by those who have not seen their effects, was well illustrated by one case which I saw: a piece of a bronze cinder cooler which exploded when it was cut by iron was picked up within so few seconds of the explosion that it was still hot at a distance of 300 yd. or more from the furnace, and in such a location that it could not have been thrown directly from the cinder cooler, but must have ricochetted from some other object. To avoid such accidents it is therefore very necessary to have the cinder notch set at such an elevation that iron will never in normal operation have an opportunity to run out through it. Moreover, if the cinder notch is set too close down to the surface of the molten iron the furnace will "lift" iron through the notch at flushing time, and this iron running along under the cinder will very frequently be entirely lost, constituting a very serious loss of product.

The reason why charcoal furnaces, especially those working on rich ores, sometimes run without flushing is twofold: First, the slag volume is relatively small and so does little harm; second, since it is impossible to remove all the slag through the cinder notch the smaller the total amount the larger the proportion of it which must remain in the furnace even after flushing, so that it is sometimes not worth while to flush at all.

Casting the Furnace

As the molten iron descends into the hearth its level gradually rises. I have already described the danger to which water-cooled bronze parts are exposed by the cutting action of molten iron. When the iron does not run across them, but only lies in contact with them, the danger is much less, but it is still great, and, as we have just seen, the cinder notch is located so that in proper operation the iron is withdrawn before it reaches the level of the cinder cooler. The capacity of the hearth up to a safe distance below this point is a measure of the quantity of iron which should be allowed to gather in it, and this in conjunction with the hourly product of the furnace is the fundamental controlling factor of the frequency with which the furnace must be cast. (We speak now of casting the furnace; presumably the original phrase was casting the iron, in the sense of throwing it or discharging it from the furnace, but the former term is in universal use among furnacemen.)

Until within quite recent years it was the almost universal custom to cast four times a day, but with the increase in outputs which came with the Duquesne Revolution the capacity of the hearths of existing furnaces was not sufficient to hold the increased output for this length of time, and furnaces were cast five, six, and even eight times a day. There is, however, a certain amount of labor involved in preparing for each cast and cleaning up after it. The iron runners have to be made ready before and generally cleaned after cast, the skimmers must be set, the iron trough grouted, and various other practical but nevertheless imperative details attended to before and after this important rite can be performed; therefore the more casts the more work, and the increased outputs were soon followed by larger hearths to give greater storage capacity for iron. Perhaps it would be at least partly correct to say that the larger hearth made the increased output possible, and after a certain point was reached this was true.

In addition to the increase in diameter the depth of the hearth below the tuyeres was increased so as further to increase its capacity, and this practice has now so far developed that H. A. Brassert has spoken of the possibility of only casting three times a day on some furnaces, and declares that even this number may be reduced.

Personally I believe that the reduction in labor by reducing the number of casts per day below four is less than the increased risk of handling the largely increased quantities of iron, because the results of accidents occurring when the furnace is full of iron are correspondingly more serious. Moreover, while modern furnaces are provided with sufficient blowing power to make their tonnage even though there be considerable quantities of cinder up around the tuyeres, it is a matter beyond all doubt that in the older practice with poorer blowing engines the driving of the furnace would always drop, and the blast pressure would always rise when the cinder rose around the tuyeres. The action of the slag in gathering on the coke and preventing access of the air to it can scarcely be denied, and I cannot help but feel that the more the slag rises above the tuyeres in streamers blown by the blast, as already described, the greater will be its action in covering the coke and preventing the proper action of the blast upon it in the lower regions of the bosh, and the further the top of the zone of combustion will be forced upward with consequent possibilities of derangement.

It seems to me desirable, therefore, to keep the hearth as free of slag as possible, and this can most easily be done by keeping down the level of the iron on which the slag floats. Further, I believe that the advantages of having less than four casts do not compensate for the possible dangers and disadvantages. It is impossible to obtain the benefits of a water-cooled apperture through which to cast the iron in the same way that we do the slag, for the reason that there is no metal which is not cut by a current of iron running at high velocity, no matter how thorough the water cooling, and as I have already explained, the results of cutting such cooling members by molten iron are likely to be catastrophes rather than accidents, involving certainly many hours of delay on the furnace, with possibly great physical damage to it, and, worst of all, almost certainly, serious injury or death to the workmen around the front of the furnace. We are, therefore, compelled to use refractory materials, and in common practice there is only one used for a base, fireclay, though other substances may be mixed with it. This is rammed into the tapping hole at the conclusion of each blast by a method which may be best described in advance of describing the operation of casting itself, because the two are so interdependent that to say which comes first is like answering the old riddle, "which comes first, the hen or the egg?" At the conclusion of cast we have a hole 3 to 6 in. or more in diameter, but preferably only 3 or 4, leading inward and downward into the hearth of the furnace, through which the contents of the latter have just been discharged.

It would seem at first sight remarkable that the hole should lead downwardly into the furnace, since it would seem that the furnace could not drain itself properly through a hole so located, and it would not except for the pressure of the blast which, as we have seen in an earlier chapter, is equal to that of a column of iron several feet in depth, and which, therefore, lifts the iron and slag through the tapping hole, the latter acting as an inverted siphon. When the blast is taken off the remaining molten material drops back through this hole into the hearth and out of the way, so that there is no dribbling of molten iron through the tapping hole while it is being stopped.

Until a few years ago it was the universal custom to

stop the tapping hole with balls of fireclay driven in by a stopping hook operated by hand labor, but as pressures and outputs rose, resulting in a greater depth of molten metal in the hearth, and a greater pressure of blast on top of it, it became increasingly difficult to drive the clay in far enough by this means to prevent this combined pressure from forcing the iron out through it, and once a trickle of this kind started it was rapidly enlarged by its own cutting action until it was soon beyond control, constituting a "breakout at the tapping hole" which, while less serious than one through the hearth jacket, was a mishap of no mean proportions, particularly if it occurred before the iron trough was grouted, the skimmer set and the sand beds made up ready to receive the iron, these representing general practice at that time.

About twenty-five years ago the late Samuel Vaughan, then superintendent of blast furnaces at Johnstown, Pa., in order to overcome these disadvantages invented the "mud gun." This consists of a steam cylinder carrying in front of it a smaller cylinder much after the general style of a direct-acting steam pump, the pistons of both cylinders being connected to the same rod. The forward or mud cylinder is open at its front end, provided with a nozzle some 3 or 4 in. in diameter, the cylinder being 7 or 8, depending upon the size of the furnace. A hole is provided through the mud cylinder just in front of the piston when the latter is drawn back into its farthest position. This front cylinder is loaded with tempered clay, plastic but quite stiff. At the conclusion of cast this whole apparatus, which is mounted on a small jib crane hung to one of the furnace columns and connected to the steam by swing joints or hose connections, is swung around in front of the furnace, the nozzle of the mud cylinder is entered into the tapping hole, then a pair of dogs or cams on a shaft running across the two front columns take hold behind two lugs on the mud clyinder, and by the rotation of the shaft force the nozzle down hard into the tapping hole. The hand-operated valve which controls the steam supply is quickly opened and the whole charge of clay is shot into the tapping hole. After allowing it to stand for a few seconds the piston is withdrawn and clay balls fed by hand into the opening at the rear of the mud cylinder. These in turn are rammed down to place by throwing on steam and driving forward the steam piston; the mud piston acts as a combined piston and steam hammer, being used not only to push but to pound the clay down into the hole.

As at first designed the shaft which holds the gun to place was operated by man power through a lever, but a few years later Felix McCarthy of Pottstown applied to this purpose a vertical cylinder fastened to one of the furnace columns, and by simply throwing steam on this cylinder the mud gun, once in place, was held securely without the necessity of any men to hold it, the only men required being the keeper to operate the hand valve of the steam cylinder on the mud gun, and a helper to feed clay balls into the mud cylinder.

With this powerful apparatus there is virtually no limit to the amount of clay which can be forced into the front of the furnace, nor to the solidity with which it can be driven in. The danger from kicks of iron and slag due to the contact of the wet clay balls was very great in the days of hand stopping, men were frequently burned by the iron stopping hook driving through the clay stop and striking molten iron, or by some of the other minor explosions which are almost universal coincidences of the contact of wet material of any kind with molten iron and even molten slag. This danger is entirely eliminated by the mud gun, as is the terrific manual labor of driving clay into the front of the furnace while standing right over the top of the iron trough heated to a white heat by the iron and cinder passing through and remaining in it.

Moreover, this invention has done more to make it easy to cast the furnace than all the other attempts along that line put together. In the days of hand-stopping the clay necessarily became more or less intermixed with iron and slag in the tapping hole, and these, (particularly the iron) enmeshed in the clay, becoming cold, made exceedingly difficult drilling. Then, too, owing to lack of power, the tapping holes were very short, only a few inches in length, like an irregular hole punched through a very thin wall, and the result of this was to permit the iron to come very close to the outside of the hole, and the resulting matted mixture of clay, iron, and slag was burned in many cases to a hardness almost beyond that of the drills. By the use of the gun two things are accomplished: First, sufficient clay to fill the tapping hole solid full is thrown into it almost instantaneously, and with such power as to sweep all liquid material before it, the clay acting almost like a solid piston flowing into the hole. This prevents the intermixture of the iron and slag with the clay, and eliminates the difficulties which arise from that condition; second, the hole is carried so much longer that it reaches well toward the center of the furnace. In the old practice the tapping hole was at the bottom of a sort of pocket in the hearth opposite the front of the furnace, and was the farthest point away from the heating influence of the tuyeres. With the use of the gun this pocket is entirely eliminated; so much clay is forced into the front of the furnace as to put the inside end of the tapping hole inside the line of the hearth proper. The consequence is that instead of having to drive or drill through a chilled convex surface of exceedingly hard material we have now only to drive through a concave surface of material almost at a white heat, and not hard because free from iron and slag, although by its thickness mechanically strong enough to resist the pressure. This being a pure refractory clay, offers more resistance to heat than it did when intermingled with fusible substances like iron and slag.

In very recent years two or three apparatus have been designed whereby the mud gun can be thrown into the tapping hole by purely mechanical means operated by a steam cylinder, so that the furnace man, standing at a distance, can turn steam on the control cylinder, throw the gun into the tapping hole, hold it there, and then turn the steam on the gun cylinder proper, throwing the clay into the tapping hole. The result is that this operation can be done even when the iron is running full force from the furnace. This was impossible in the days of hand-stopping, and exceedingly difficult and dangerous with the mud gun when the latter was swung in and locked fast by hand, though I have known cases in which furnace men of unusual nerve and presence of mind, seeing something about to go wrong with the disposition of the iron, such as filling all the ladles available before the conclusion of the cast, or the like, have succeeded in throwing the gun into the hole and stopping it with the iron running full force. With the modern mechanically controlled apparatus this can be safely done as a regular practice. The consequence is that the blast does not require to be taken off the furnace, with the consequent disturbance in the rate of settling of the latter, and casting instead of definitely ending each period of furnace work becomes merely an occasional incident in its steady and continuous operation.

Opening the Tapping Hole

This operation was carried on until quite recent years by drilling with hand drills. Sometimes one man held

and guided a chisel bar while his helpers drove it with sledges virtually in the way that old-fashioned drilling for mining was done, or in other cases a gang of men from four to ten or twelve were put on a long churn drill whose weight was sufficient to make it both drill and hammer in one. Drilling was carried on until the temperature and the physical condition of the material at the bottom of the hole showed that the iron was very close, when the drill was generally removed and a bar driven by a sledge to break the remaining skull if there were any. In many cases with churn drilling the drill broke through the skull and the iron came without the necessity for driving the bar.

This was the practice in the days of pig beds and hand labor for everything. Now the number of men on the furnace is not sufficient to operate one of these huge churn drills, while the easier drilling produced by the use of the mud gun as just described has made these powerful blows unnecessary, and the hole is drilled out either by light sledging on a small chisel bar, or else a clay auger driven by a compressed air or electric motor is used. This is held and fed down into the hole by two men. When they see that they are close to the iron the auger is removed from the hole and the skull broken by a steel bar driven by a hammer as just described. This reduces the labor of casting the furnace to a fraction of what it was in the older practice, even with a regularly working furnace; when the furnace was working irregularly under the old conditions there was never any telling how much time or labor would be required to get the tapping hole open. The red-hot material composed, as I have indicated above, of clay, iron, and cinder could be drilled in to a certain point at which its temperature was so high as quickly to dull the edge of the drills, while it was still so hard and at the same time so tough that to drive a bar through it was often an impossibility. Consequently, it was no uncommon thing to see furnaces require two, three, and four hours to drill open the tapping hole, which should have been done when things were working properly in ten or at most fifteen minutes.

This drilling with a churn drill is by no means a gentle exercise; a few minutes of it will temporarily exhaust even a powerful gang of men, so in a case of this kind two relays of men must be provided, while the drills are dulled so quickly that two crews of blacksmiths are not always able to keep crews supplied with drills. Of course, these frightful conditions only occurred semi-occasionally, but the impression which they created when they did come was a lasting one.

The labor and expense entailed by these conditions is the least serious part of the difficulty; the design of the furnace as I have above indicated is such that the well or hearth will hold the iron made between two consecutive casts with a safe margin. At the end of an hour this margin, in the old days at least, was likely to have disappeared. The iron would then be up to the cinder notch, while the cinder would be well above the tuyeres, and only kept out of these by the pressure of the blast. The stopping of the blowing engines would have filled the blow pipes and the penstocks and cause hours of delay, yet to continue blowing constantly increased the height of the iron and cinder. Up to a certain point it was considered safe to open the cinder notch and flush the cinder; after that it was certain that the iron would be above the cinder notch, and the question was whether to take the risk of the damage that the iron would almost certainly cause by rising around the tuyeres, or risk the danger of flushing it through the cinder notch with the likelihood of cutting the monkey or the cooler and producing a disastrous explosion. It was one of those conditions in which it was out of the question to stop, and yet to go on seems like destruction. There was nothing for it except, perhaps, to slow the engines down as far as was safe and to hope that the attempts to open the tapping hole would succeed before the catastrophe came, whatever its form might be.

Owing to the vastly better conditions, and the almost perfect control which the mud gun gives us of the tapping hole these bad hours are now very generally a thing of the past. I am sure that no one who has ever been through the experience will regret this fact.

Blowing In

The blast furnace is essentially an apparatus which operates not for days nor weeks, but literally for years at a time. It is virtually impossible to operate it at all except on an absolutely continuous basis. The reason why this is so, while not difficult to understand, is not exactly self-evident, and a brief explanation may not be amiss.

We have seen that fundamentally the operation of the furnace consists in maintaining a continuous downward current of solid material which starts in solid at the top and comes out molten at the bottom, and an opposite upward current of gases which attain their maximum temperature a fraction of a second after they enter the furnace, and cool off progressively as they rise through it, being discharged at the top at a temperature lower than that of the waste gases from even the best boilers, sometimes down to 200 deg. Fahr. These materials exercise a counter-current effect, both physically and chemically, upon one another throughout their passage. This means that the condition at any point in the blast furnace is the result of a floating equilibrium between the heating and reducing action of the ascending gas and the cooling and oxidizing action of the descending solid at that point.

In good practice the conditions at any given zone are practically constant throughout for an almost indefinite time, but the conditions in the individual particles of matter change rapidly from second to second in the case of the gas, and from hour to hour in the case of the stock, and each of these exercises an effect upon the other. For instance, let us suppose that the top gases are discharged from a given furnace at 400 deg. Fahr.; now if we go down a short distance we shall reach a point where these gases are 1000 deg. They are cooled from this temperature down to 400 by the action of the incoming stock, which they pass on their way up. On the other hand, the stock entering at, say, 70, descends to this point, and in so doing is heated up, let us say, to 800 deg.

If the operation be regular and normal the gas will always be about 1000 and the stock always about 800 at this point, but suppose that we ceased to fill the furnace regularly and continuously, then the surface of the charge descended to this point. Obviously conditions below this would be just the same, but the conditions above would be very different. The descending stock becomes heated, but without the addition of further charges the temperature of the gas rises steadily until when the surface of the stock column reaches our chosen zone the gases are obviously passing off at 1000 deg., there being now no stock above this zone (at which they reach this temperature) to cool them any further. Obviously the heat in the gas from 400 to 1000 deg. is gone, permanently lost as far as the furnace is concerned. Now if we begin charging against the stock which should reach this zone with a temperature of 800, reaches it instead with a temperature of 70, and is behind its schedule by as many hours as it takes in normal operation for a charge to descend to this zone,

while the heat which should have raised this fresh charge to 800 is, as we have seen, lost, and has left the furnace forever.

The result is that this charge has had several hours less treatment for its reduction and has received much less heat than it should. If the zone to which it fell when charged is not down too far, that is, if the stock line has not been allowed to settle too far, if, in furnace parlance, the furnace be not too far down, and if there be a surplus of heat in the upper part of the furnace, as there generally is in coke practice, then the lost time and heat may be made up; but the further down the furnace is the more certain it becomes that this will be impossible and that this charge and those immediately following it will reach the hearth improperly prepared and that the regular operation of the furnace will be upset by this condition, the seriousness of the derangement being in a general way proportional to the amount of time these charges have lost.

We can carry this supposition a step further. Suppose that the top surface of the stock were permitted to descend to the level of the top of the bosh? Obviously the gas would pass off at a temperature of 2700 or 2800 deg., representing a very large proportion of all the heat developed, and if the furnace were driven at the same rate any stock which entered at this point would reach the hearth in a very short time in such a completely raw condition as to make impossible the production of iron from it.

If we carried the process a step further, and allowed the top of the stock to descend to the tuyeres, obviously the furnace would be virtually out of commission, the quantity of heat carried off by the gases would have been so great, and the time permitted for the absorption of heat by any incoming charge would be so small, practically zero, that we should have nothing but raw stock in the hearth of the furnace if we charged at such a time. Now suppose we reversed this process and filled the furnace up completely just as though it were in regular operation, and let us suppose for convenience sake that this operation could be done instantaneously. Instead of having a furnace full of material in all the stages of reduction and heating, from nothing up to completeness in both respects, we should simply have a receptacle full of cold material, and while the heat generated by the combustion of the coke in the charges at the tuyeres would warm it up it would obviously be impossible for this amount of heat, without the assistance of that of the gases which had gone before, to complete or even to come anywhere near completing the smelting operation.

This represents in a rough way the conditions which we have on blowing in a furnace. We fill it necessarily with cold stock from bottom to top, and then put fire in at the tuyeres and put on the blast. The material in the bosh instead of being molten is cold, and if we had a burden of the ordinary kind on the furnace it is obvious that we should never get it to the liquid condition so that we could remove it, to say nothing of reducing the iron contained in the charge.

Moreover, there is another large factor which exercises a precisely similar effect. The walls of the furnace weigh many hundreds of tons, and the interior surfaces of these when in operation are at the same temperature as the zone of the furnace which they inclose, and while the outer portions of the walls are not so hot, still the amount of heat contained in the walls in normal operation is enormous, it is probable that it represents the thermal value of the coke burned for a considerable fraction of a day. When blowing in these walls, of course, are perfectly cold, and it is impossible for the different zones of the furnace to acquire their proper temperature without simultaneously raising that of the walls at these zones to the same point.

In blowing in the furnace to overcome this condition, therefore, we must charge a great quantity of fuel without any burden whatever. This mass of fuel fills the furnace up to a considerable portion of its height, probably in ordinary practice from one-fourth to one-third. It is clear that when this has burned away, and the material above it reaches the tuyeres, it will have had the benefit of the heat in the gas coming from this great mass of fuel, and that it will have been several hours in its descent while this mass of fuel is burning away. Such superincumbent portions, therefore, will have a vast advantage in time and temperature over the initial coke at the tuyeres. In practice we take advantage of this condition by putting on a very small amount of burden, with an extra large coke charge, two or three times the normal size, and then very gradually increase the burden and decrease the coke charge until finally the furnace is filled. The rate of driving while blowing in is very slow, for reasons to be given later, and this extra time which this gives especially to the upper portions of the charge, combined with the excess fuel, finally brings the different zones approximately to the temperature which they should have in normal operation, and the furnace then begins slowly to produce iron.

After the heavy blank of coke in the bottom occupying, perhaps, 25 to 35 per cent of the total volume of the furnace, according to the best judgment of the manager, has been charged, the burden is gradually increased until at the top it reaches a ratio of one to one; that is, about 1 ton of ore to 1 of coke, which is virtually half of the burden in regular operation. After lighting and blowing for several hours cinder appears and is flushed, and after twelve to twenty hours, according to the conditions and the judgment of the manager, enough iron accumulates to make it worth while to cast; during this interval the furnace is being driven very slowly, and as it settles is filled with charges slowly increasing.

After the first cast the furnace has approached so much more closely its normal conditions of temperature in the different zones that the burden may be increased more rapidly, the only guide being the indication of each cast as it is made, the appearance of the cinder, and the general conditions in the hearth as determined by looking into the tuyeres, but the furnace man who is satisfied with the way it is progressing, knowing that with normal progress each cast will be hotter than the next, increases the burden in advance so as to prevent making too much high-silicon iron. Where the practice is well standardized, and where there has been previous experience in blowing in with the same materials, it is possible to bring the furnace down on irons of the desired analysis at the first cast, and to increase the burden as needed so as to make nothing else during the blow in.

The tendency in recent years has been to shorten very much the period required in older practiceto bring the furnace to normal operation.

Leaving the question of burdening we turn toward the next most important question, that of the volume of wind at the different periods of blowing in. This must be very much smaller than the normal blast blown in the furnace in normal operation for two reasons: First, to allow the effect of time to replace in some measure the deficiency in exposure to heat from which the materials first charged suffer, it being obvious that the longer these are exposed to the rising temperature due to the gradually increasing heat of the furnace the more nearly will they reach the condition they should have

at the different zones; second, the walls of the furnace are cold, as already described, and time must be allowed for these to heat up, and the blast must be encouraged to travel up them by the use of short tuyeres rather large in comparison with the quantity of blast blown because if relatively high penetration be used, especially with the open mass of coke in the hearth and bosh, the tendency of the blast is to travel to the center of the furnace and to pass up through this region like a chimney, leaving the walls relatively cold. Then as the slag begins to form it runs down, and striking on the sloping surfaces of the bosh is chilled there and so builds up, in some instances forming a shelf-like structure on the bosh walls, which is nearly if not entirely fatal to the success of the campaign being started.

I knew of one case in which a furnace was blown in on a very large volume of blast for its size, and this was blown through a small number of tuyeres, which gave excess penetration. The furnace worked so badly that at the end of a week it was blown out. When its operators went inside to see what the conditions were they found a shelf built on the bosh walls. The opening between the noses of the two shelves being something like 3 ft. 6 in. in a furnace whose bosh diameter was about 18 or 19 ft.

This seems almost incredible, but the facts were given me by the manager, who certainly had no reason to be proud of the performance, and there is every reason to believe that the story is authentic. The cause in this case is obvious; the high penetration drove the blast to the center and left the walls so cold that the cinder running down over them froze to them, and probably after a short time began increasing the bad effect, which was initially at the bottom of the trouble, by forcing the blast more and more toward the center.

For both these reasons then the quantity of blast used at blowing in is a small fraction of that used in normal operation, probably, in ordinary practice, about a third. This is increased very slowly at first, and at all times more slowly than the burden until the latter has reached about the figure for normal operation at the end of one or two weeks. Then the blast continues to be increased until it in turn has reached its normal amount and the furnace may be said to be in full operation.

Lighting the Furnace

The practice in this respect has varied over the widest possible range. My father, the late Joseph E. Johnson, told me that the practice of the old Southern charcoal "founders," who were entirely illiterate, was to light the furnace at the *top* and allow the fire to work down through the fuel column to the bottom, filling up above as the charcoal burned away, a process which took a week or two even with those tiny furnaces. Anything more absurd than this performance it is impossible to conceive.

As a result of this and some other practices based on reasoning about as fallacious, the furnace when blown in on one occasion got into such a horrible "mess" that at the end of three weeks it was blown out as being hopeless. They filled it and started again, and in a short time it was in worse condition than it was on the first occasion, but this time for shame's sake he insisted that the founder keep on, and they finally pulled the furnace through, rather in spite of that individual than with any help which the latter gave them.

These events took place in the early seventies, now more than forty years ago, but considering the changes which have taken place in this as in other departments of this business the time required for the transformation does not appear very great.

After the practice of lighting the furnace at the bottom was established up until very recently it was the custom to put a large quantity of wood into the hearth. This practice is still followed at some plants; in one case it is varied by using a carload of charcoal for the bottom of the furnace, this, of course, being very expensive in most localities.

When wood is used it is put into the hearth with the greatest care. In some cases in former times, and perhaps still at some plants, a scaffold or platform inside the hearth was built of wood and the cord wood was carefully placed on top of this, so that when the fire had burned the scaffolding sufficiently to break, the stock was given a sudden drop which started it to settling, it being a tradition, based, I think, on the rather defective practice of an earlier day, that it is very difficult to start a furnace to settling when it is blown in. When the scaffold was not used the wood was stood up vertically in the hearth and built up at least two lengths of cord wood 8 or perhaps 12 ft. or more, a small shaft being left to the last through which the wood, passed in through the tuyeres or tapping hole, could be taken up to the upper ranks, and through which the man who placed the wood could get down when that operation was finished.

In more recent years the tendency has been to discard the use of wood almost altogether. A few sticks placed around the tuyeres with a little kindling between them and the tuyeres are a convenience in getting the furnace lighted quickly. A few pounds of waste soaked in oil, pushed in through the tuyeres and ignited just before the blast is put on will ignite the coke with the use of no wood at all or at least only as much as may be put through the tuyeres. This saves a great deal of bother and in most cases saves a very considerable expense of cord wood, which costs several times more per unit of heat contained than coke.

One feature of practice in blowing in due to the dread of having the furnace hang at this time now fortunately belongs to a bygone era. It was then believed that the great height through which the stock had to fall in the early stages of filling the furnace tended to pack it solid and prevent the gas from rising, on the one hand, and the stock from settling, on the other. In order to avoid this difficulty, I am told that the practice was one time followed of lowering the stock into the furnace in tubs at the end of ropes, the tubs being dumped only when they were within a short distance of the stock already charged. I am extremely glad to say that I never had the misfortune to experience this operation, which is entirely obsolete as far as I know.

The universal custom now is to charge the furnace from the stack (after the wood had been placed, if any be used), exactly as is done in regular operation.

In former times it was customary to allow the furnace to draw, that is, leave the tuyere caps down and let the furnace act like a chimney, its draft, of course, being very greatly impeded by its being filled up with stock, over a period of hours ranging from two or three up to twenty-four.

I have seen this practice followed a number of times, and I have also seen and used the more recent practice of putting the blast on as soon as the furnace is lit, and I have never been able to see any advantages whatever in the old practice, whereas there are several in the latter. One of these is that the slow fire drawing gradually up through the furnace has the chance to bring some material to a half-molten condition and cause it to stick, while a quick blow-in does not. Another is the elimination of a half day or even a day of lost time and "sneaking" gas. I have never used the scaffold to cause the settling of the stock, but in recent years I have fol-

lowed a practice whose benefits I found almost by accident, and that is to give the furnace, for a few minutes after the fires at the tuyeres are well caught, about twice as much blast as it is expected to use for the rest of the blow-in. This drives the fire well to the center of the furnace to start off, and producing a brisk action before any pastiness has had a chance to arise from slow combustion induces a quick initial settling of the charge, which thereafter proceeds regularly on the reduced blast used for the rest of the blowing-in period. This practice also has an advantage in bringing down the gas, as it is called.

Bringing Down the Gas

When the furnace is first lit the interstices in the stock, the space above the stock line, the downcomer, and the dust catcher, and the flues leading to the burners on the stoves, boilers, etc., are, of course, all filled with air. Air mixed with furnace gas in a very wide range of proportions is highly explosive, and it was until very recent years considered a difficult feat to bring down the gas without having an explosion of more or less violence, because when the gas began to come through, driving the air ahead of it, the point would finally be reached where the mixture was a combustible one, and the flame striking back from the burners would ignite this mixture, and traveling back from the flue at least throw open all the explosion doors, and at worst burst the dust catcher or blow down part of the boiler settings.

In recent years there have been found two methods for avoiding this trouble which can be practiced separately or, still better, together. The first consists of providing at the extreme end of the gas flue, or on each end if it has several branches, an outlet with an explosion door, or other arrangement capable of being easily closed with the gas passing through it; the burners are all shut off tight, and the bell and other openings into the furnace and gas main system tightly closed, all the gas is then forced to pass off at these flue-end openings, from which all fire is carefully kept away. When a solid column of gas appears, which can easily be told, both by its appearance and its odor, the burners on the stoves and boilers are opened one at a time, and the dangerous mixture having all been pushed out of the flues far from these no explosion can possibly occur. The flue-end vents are then closed and all danger of explosion is over as long as the blast is kept continuously on the furnace.

The other expedient is one first used in the Birmingham district about the first of the present century. It consists in introducing a blanket or cushion of steam into the top of the furnace, dust catcher and flues before or at the time of lighting. This drives out all the air except the small amount in the interstices of the stock, and thereby prevents direct contact of the gas when it begins to rise with a sufficient quantity of air to produce an explosive mixture. When a sufficient volume of gas has passed to drive this cushion of steam out nothing but practically pure gas is left, and this may be ignited at the burners in safety. It is better, however, and safer to use this method in conjunction with the other by permitting the steam cushion to be blown out at the end vents of the gas flues, and thus securing the benefits of both methods. The steam-cushion method has in recent years been quite widely introduced by Mr. John W. Dougherty.

The benefit of a few minutes of extra blast in connection with bringing down the gas is that instead of having a very small quantity of gas formed, which appears to be almost lost in the interstices of the stock for quite a while, and which, therefore, prolongs the period within which air mixture may be made and explosions follow, a considerable volume of gas is formed at once, and sweeping through the furnace drives out the air and shortens the period during which accidents may occur, as well as starting the stock to settling without delay.

Warming Up the Furnace Bottom

The bottom of the furnace contains many tons of brickwork which under the very best conditions can only have been warmed to a very slight degree by the drying-out fires previously described, and its temperature is many hundred degrees below the melting point of iron and slag. It therefore has the inevitable effect of chilling these and making the first tapping and flushing of the furnace extremely difficult. It has for a long time been the custom to leave the tapping hole open so as to allow the part of the gas formed at the tuyeres to blow down and pass out through this, thus making a downward current and warming the sole of the furnace. The tapping hole, however, as built in the brickwork is generally 2 or 3 ft. high, and if left entirely open the tendency of the gas would be to pass out through the top and not go to the bottom as it should. Moreover, it is necessary to have the tapping hole under control so that it can be closed at the first appearance of cinder, as not enough of this flows at first to keep on running, and cooling gradually it would build up until the hole could neither be opened nor shut without horrible difficulties.

This situation is met in recent years by placing a 4-in. pipe in the bottom of the tapping hole, running it well towards the center of the furnace, and filling up the space around this pipe with clay, sometimes mixed with fine coke braize so that it will not burn too hard. In the best practice this is built out to a convex surface well inside the line of the hearth proper, so that when the time to tap the furnace arrives the final point at which the body of iron is penetrated will be warmed as nearly as possible on all sides and so be made easy to penetrate.

Mr. R. H. Sweetzer has introduced an improvement in the use of the pipe by drilling holes in its outer ends through which it may be caught by means of long hooks and pulled out of the furnace when the slag begins to run, thus leaving a clean hole 4 or 5 in. in diameter in the clay which may readily be stopped with clay balls. The pipe is not removed for many hours after the blast is put on the furnace, not in fact until the flow of cinder becomes so large that it threatens to plug up the pipe by progressive flowing and freezing. The gas burns fiercely out the end of this pipe and helps to warm the iron trough outside, a point of very great importance, in order to prevent explosions when the molten iron strikes a cold iron surface.

The whole operation of blowing is one of some complexity, and it is virtually impossible to treat it completely here, there being many details which are neither comprehensible nor interesting, except to practicing furnace men, who commonly do not need to obtain them from books.

There are, however, a number of points in connection with blowing in which are worthy of mention. The practice of charging cinder saved from a previous blast on the blowing-in charge has been quite extensively followed and has much to commend it. High-temperature operations during the initial stages of blowing in are at a very serious disadvantage as the furnace temperatures are still too low for their accomplishment. We have already seen that the temperature required to form slag is considerably higher than its melting point, therefore a slag which has been completely formed melts much more easily and runs more freely at the tempera-

tures available during blowing in than the substance to be slagged, notably the coke ash, even though the latter have limestone charged with it.

Another reason for the use of slag is that a large volume of molten liquid is much less likely to become frozen and troublesome than a larger volume of the same liquid, the surface exposed by the larger volume in general being but little greater than that exposed by the smaller, therefore to increase artificially, so to speak, the volume of slag is a benefit and tends to prevent that troublesome occurrence of progressive building up through alternate blowing and freezing of which I have spoken. The practice of adding old slag is not as common as it once was, but its use is well worthy of consideration.

Slagging the Coke Ash

The great quantity of coke used as the initial portion of the blowing-in charge containing about 10 per cent of ash has in the aggregate several tons of slag-forming material, very largely silica and alumina with but little lime for flux. This makes alone a tough, stringy, hard working slag. It is very much better on every account to add to the coke as it is charged a sufficient amount of lime to flux this ash to the best advantage. As the first slag should be out of the furnace before any iron comes down it is not necessary that this first slag should have much sulphur-carrying capacity. It can be made much more fusible than the normal coke furnace slag by the use of a considerably smaller percentage of lime, thereby reducing both its quantity and melting temperature, but the slag produced just previous to the carrying down of the first iron should be slag almost of normal lime content, perhaps somewhat lower than this both for safety and because if the furnace is as hot as it should be, less lime is sufficient for desulphurization.

Pre-Heating the Stoves

The blast furnace process as a whole constitutes in a sense a cyclic operation. The blowing engines and the stove supply the blast which drives the furnace and the furnace in its turn supplies the gas which runs the blowing engines and heats the blast. But at blowing in a single furnace these conditions do not prevail. There is no gas available until after the furnace has been started. It is therefore necessary to fire the boilers with coal to make steam in the way customary where blast furnace gas is not available.

The stoves present a more difficult problem. We have already seen that under the very best circumstances the material which starts at the tuyeres when the furnace is blown in is nearly 3000 deg. below the temperature which it should have at that point. The blast is normally 1000 deg. or more when entering the tuyeres. If now with blowing-in we add to the effect of the cold stock inside the furnace the effect of blast 1000 deg. cooler than that which we should use it is obvious that we shall be a long time building up the temperature we require, and those who had the experience of it know that even 400 or 500 deg. of heat in the blast at this time is a great help as compared with cold blast. The stoves being entirely unprovided with grates cannot be fired to advantage with anything but gas, although a bonfire may be kept in the bottom of the combustion chamber by wood pushed through the burner or clean out openings, and this at least should always be done for several days continuously before blowing in.

Very much better than this, however, is the plan of building a temporary oven outside one of the air or clean-out openings best suited for it, arching it over or covering the top and connecting its outlet into the stove opening. Grate bars are then placed in the oven and a good coal fire kept in it. The hot gases from this fire pass directly into the stove and if the operation be carried out with a little care and for several days before blowing in the stove can be in condition to give a temperature of several hundred degrees when it is finally wanted on the furnace. Of course care must be taken to see that the hot gases from the fire do not strike on the steel fittings around the stove openings or any metal part of the stove.

The question of drying out the furnace has already been discussed under the subject of lining and need not receive further consideration here.

Banking the Furnace

In the article on "Thermal Principles" the losses by radiation and cooling water were given in terms of thermal units per ton of iron, and while this is necessary and right for the purpose then in view, it must be remembered that heat losses are proportional to temperature and to time, and under given conditions to nothing else. Hence if we maintained the temperature of all the zones of the furnace exactly as it is in operation, but stopped the operation, made no iron, we should lose precisely as many thermal units in twenty-four hours as we do when the furnace is in full operation. We can put this into a more easily comprehensible form. If the total heat losses be 750 thermal units per ton, and if the furnace produces a ton of iron every three minutes, or 480 tons per day, we shall have a loss of 250 thermal units per minute, or in ten hours 336,000,000 thermal units. This is as much as is required for the smelting of twenty-five tons of iron, or in twenty-four hours we should lose as much heat as was required for the smelting of sixty tons of iron.

This loss is constant if the temperature of the furnace in all its zones be maintained constant, whether we make 500 tons per day or none, but if we make 500 tons per day the loss only represents 10 per cent of the heat developed, and this the furnace can stand, but when no heat is being developed the furnace cools off very rapidly and of course the most rapidly in the zone of highest temperature, that is, the hearth. This means that the iron around the edges of the hearth soon begin to freeze and instead of having merely a thin scull of frozen iron to break through in tapping the furnace we shall have a scull of red-hot iron many inches in thickness, too hard to drive through, and much too tough and hot to drill except by the most tedious work. The consequence is that if a furnace shuts down for even a few hours in the regular course of normal operation much difficulty is experienced in opening the tapping hole, and the cinder notch, and in removing the frozen iron around the tuyeres which is often low in carbon and therefore tough, almost like wrought iron. Under these conditions operation can only be resumed with difficulty approximately proportional to the length of the stop. If there be iron in the hearth when the furnace is shut down this quickly freezes solid, filling the hearth with solid material, thus making it almost impossible to put the furnace back into normal operation. Because of course the regular tapping hole is frozen solid and cannot be used, the frozen iron in the hearth cannot be removed and the new iron formed when the furnace starts is raised far above its proper level and is continually threatening the cinder notch and tuyeres, while the mass in the hearth being heated only from the top melts very slowly. The furnace must be cast through the cinder notch or even through a tuyere, and in general the conditions of operation are terrific, nothing being arranged for those conditions.

For this reason if the furnace must be stopped for more than a very few hours provision is always made

for it in two ways. First of all by casting and removing as far as possible all the iron and cinder so there will be nothing left in the hearth to freeze. In good practice precautions are often taken in the stopping of the tapping hole; sand or braize is mixed with the clay for stopping the tapping hole so that it will not burn too hard. Second: if the stop is to be more than a few hours duration and if it be known beforehand that it is to be made, a blank of coke is charged at such a time that it will have descended about to the tuyeres by the time the stop is to be made. This gives an excess of fuel supply which becomes available as soon as the furnace starts up, and this excess heat is of the greatest use in restoring normal operating conditions.

Another beneficial feature is that the ore and limestone being absent from this coke charge there is correspondingly less molten material to descend into the hearth and freeze there while the furnace is stopped.

The size of the blank depends upon the length of the stop to be made. For a stop of a few hours duration only a single blank charge of coke may be used. But for a stop for two or three days a blank many times this size is required, and if the furnace is to be shut down for many days or perhaps several weeks, or indefinitely, as sometimes happens, then the furnace is practically filled altogether with coke.

After the furnace is stopped the greatest pains must be taken to shut off the tuyeres absolutely tight so as to prevent air from entering through them by natural draft. For very short stops this may be done by ramming clay balls through the blow pipes into the tuyeres and packing them there, while for longer stops the blow pipes are taken down and the tuyeres removed and a tight stop of clay put into the cooler. Of course the cinder notch and tapping hole are kept closed and if there are any cracks which have been blowing gas these should be luted up with clay.

It is surprising the amount of air which will draw into a furnace and the rate at which combustion will go on without blast unless special pains be taken to prevent it. This is objectionable because it burns up coke to no purpose and produces a corresponding quantity of slag in the hearth with the possibility, not to say certainty, that it will freeze there and make trouble on starting up. On long shut downs the cooling water on the furnace should be cut down to the merest trickle so as to prevent the removal of any more heat by this means than is absolutely necessary.

By following these precautions furnaces have been banked for months and then successfully started up again, but even with the best of management the long period of inaction is likely to bring about the sticking of material on the walls, and the consequent formation of scaffolds, such material would be scoured off as fast as formed during operation and scaffolds would therefore not occur. Moreover, even with the best of management the hearth builds up and its capacity is diminished, and in general that careful adjustment of all the conditions which the furnaceman may have been months in bringing about is upset, so that it is very rare for a furnace to work as well after a shut down as it has before for a considerable interval of time, this interval being in a general way proportional to the length of the shut down. That is to say, a furnace will quickly recover from the derangement of a six-hour shut down, but it will take in general nearly a day to restore equilibrium after a day's shut down, and a week or more when the furnace has been banked for several weeks.

The practice of banking furnaces is undoubtedly necessary at times, sometimes for physical and sometimes for financial causes, but for all these reasons it is a practice which breeds trouble, very often of long duration, and I believe that most furnacemen, if they knew in advance that a furnace had to be banked for a period of more than four weeks, would prefer to blow it out and blow it in again after the desired interval, and in my judgment this would be by far the wiser policy.

Blowing Out

We have seen that if the furnace be not kept full the gas passes off as the level of the stock descends past any zone in the furnace at the temperature which the gas has at that zone in normal operation. In other words, the temperature at that zone is approximately fixed as long as the surface of the stock does not descend below it; if there be stock above it, the gas will give up an amount of its heat roughly proportional to the heat of the stock above it, but if there be none, then the gas necessarily passes off at that temperature.

In blowing out, therefore, we lose the heat in the gas which we shall so badly need during the subsequent operation of blowing in to bring the materials of the charge up to their approximate temperatures at the different zones, but having no means to store this heat we have no recourse but to lose it. But it is worse than this; we not only lose the heat, but the temperature of the gas passing off rises from a temperature which iron and steel can ordinarily stand without any difficulty whatever, since the bell and hopper have habitually stood it for months and years together, to a temperature which is above the melting temperature of steel itself, and in consequence the gas destroys anything exposed to its action and not properly cooled.

In the days of furnaces with the center outlet and unlined downcomer, the latter could not be exposed to these gas temperatures without complete destruction and, protection to it being impossible, the entire top rigging of the furnace was taken off, bell, hopper, center outlet pipe, and practically everything of iron above the top of the furnace, this of course being done during a shut down of a number of hours for this purpose. After this operation was completed the blast was put back on the furnace and the gases allowed to pass out the top at will. They of course instantly burned on meeting the air at the top and a vast flame rising 100 ft. or more in the air was the result, this continuing until the furnace was blown out, that is, practically all the charge burned up.

In more recent years downcomers being lined throughout with brick, this condition does not exist, for while the bell and hopper are exposed to the gases they can be protected by filling the annular space between them with water and allowing enough to run into it continuously to supply that which boils away, and in consequence the operation of blowing out the furnace is much simplified. It is, however, very desirable to keep down the temperature of the gases as much as possible, and for this purpose water pipes are commonly introduced through the holes provided for the test rod and water is pumped into the furnace through these pipes, so cutting down the gas temperature very materially. I have found, however, that too heavy a column of water descending on the stock would make its way through the coke in spite of the ascent of the gas and so would chill the charge during blowing out. In order to obviate this I preferred to plug the end of the pipe and drill it full of holes for a distance of several feet so as to make a heavy spray of water. This cools the gas much more effectively and prevents the possibility of any solid body of water penetrating the coke.

When provision for cooling the gases in this way is made, and the charging space above the bell filled with water, virtually nothing more is needed but to put on the blast and keep on blowing until all the fuel in the

furnace is burned up. It is, however, desirable to have a fairly hot blowout so that the last iron and cinder to be removed may surely be hot enough to be tapped out of the furnace without any difficulty, and for this reason the burden is usually lightened somewhat.

The height to which it is desired to blow down varies according to the opinions of different furnace men. Some prefer to charge a large quantity of coke braize or poor coke which acts as a sort of piston and enables a little blast pressure to be kept upon the furnace until the charge proper is all burned out, this blow-out charge being then shoveled out after the furnace has been cooled down. The iron which lies down below the level of the outer end of the tapping hole cannot be lifted out by the plast pressure on blowing out because there is practically no stock in the furnace to make any blast pressue, and it is very undesirable to have this iron left in the furnace because it represents a decided loss of product and increases by so much the salamander which the furnaceman knows he will shortly have the pleasure of breaking up in the face of very considerable difficulties even under the very best conditions.

At one plant it is the custom to overcome this difficulty by removing the iron trough previous to the last cast, digging away the brick work on which it rests, making up a temporary sand runner to some pig beds at a correspondingly lower level and then drilling in at this lower level a foot or two below the level of the reguar tapping hole and running in as nearly horizontal as possible. This drains the furnace down to a correspondingly lower level and removes most of the iron which would otherwise be left in a puddle in the hearth to freeze.

Relining

When the furnace is blown out it is generally necessary to make all repairs needed in the minimum time so as to get the furnace into operation again and cut off the loss which arises from the continuation of fixed charges whether the furnace is in operation or not, so that such repairs are generally made under pressure. These in general are various kinds of purely mechanical operation and need not be specially described here.

The operation of relining the furnace, generally the principal single item, is ordinarily the same as that of lining, since in most modern practice the old lining is torn out completely. There are, however, many cases in which the major portion of the lining is good and it is necessary only to put in a patch to repair a portion of it. It is obviously not possible to give detailed descriptions of this operation, which depends, as do so many other practical details of this business, on the skill and good judgment of the manager.

Removal of the Salamander

There is, however, one operation which is in a class by itself on account of the number of factors involved, and the weight of the pieces to be handled. This consists in the removal of the salamander. The formation and general nature of this has already been described. Its size varies considerably. In a charcoal furnace I have seen the hearth almost perfectly clean and smooth, the iron not having penetrated into the brickwork at all, but in coke furnaces with their higher hearth temperature and slags chemically much more active, conditions are very different. The bottom of the salamander is seldom less than 3 or 4 ft. and may be as much as 8 or 10 ft. below the original hearth level. Its diameter in general bears some relation to the original diameter of the hearth, usually larger than the diameter inside the brickwork and smaller than the diameter outside. This means a mass of metal anywhere from 8 to 20 ft. in diameter. I myself have had experience with salamanders weighing between 250 and 300 tons, this including only the single piece of solid metal in the central mass and not including the smaller but separate pieces lying around it and of course not including any brickwork, nothing but solid iron. I have no doubt that much larger salamanders than this are found in the larged size furnaces of the present day with their extremely large hearths.

If the hearth jacket is a permanent structure, which is generally the case under modern conditions, it necessitates removing this large mass of metal without disturbing the hearth jacket and, above all, without breaking the latter during blasting.

This of course increases the necessity for more care in handling the explosives required for this operation and incidentally increases the difficulty of hoisting the pieces out of the deep pit so formed.

Several years ago I described the operation of removing a salamander of about 130 tons weight from a small furnace, in an article which was published in the *American Machinist*, and as this gives a fair idea of the operation even for a larger furnace, portions of it are reproduced here.

Since the time this was written several cases have come to my notice of accidents due to the failure to explode one or more of the holes charged with dynamite. In one case this took place and afterwards a hole fired, presumably by the heat of the salamander, just as the furnace superintendent crawled in through the tapping hole to see what the effect of the shot had been. By great good fortune he escaped without permanent injury, though both his eyes and hearing were in danger for a long time, and a change of only a minute or two in the time of the accident might have resulted in his being blown to atoms. It is therefore worth a great deal of pains to see that holes do not fail to fire. The wires running to the exploders should be swung up out of contact with the salamander to prevent grounding, and instead of the common battery used for blasting a powerful electric light current should be thrown into the circuit to secure a sufficient volume of current to fire all the holes irrespective of the conditions. Of course vast masses of metal like this hold their heat a long time and the greatest precautions are necessary to prevent the dynamite being discharged from the heat soaking into it from the salamander. The holes as fast as drilled should have water put in them and it is better if this can be kept running constantly so as to cool the metal around the hole for a considerable distance. After each shot the heating effect of the blast is great and pains must be taken to see that this heat is removed before the hole is recharged.

The correctness of the general principle described above has been established by experience subsequent to that operation, using comparatively small charges at the bottom of holes of only moderate depth, by far the great portion of the hole being filled with tamping, and firing all the holes at once. The great tendency of professional blasters is, as they say, to "make sure you put in enough powder and then add a few more sticks for luck." This is the worst possible practice in blasting salamanders, for the reason that the expensive and time-consuming portion of the job is the drilling of the holes, and if these be loaded anywhere near full the top of the hole is blown out into a crater and the hole is destroyed. Moreover, the pieces of iron thrown out of the crater do many times more damage than all the other blasting put together, since they act as projectiles with an enormous charge behind them, whereas the splitting of the salamander itself produces no shock except that of the blast on the air.

The Present Status of the American By-Product Coke-Oven Industry

In our issue of May 1 we gave on pages 502 to 504 a report of a very interesting paper, read on the American by-product coke-oven industry by **Mr. T. C. Clarke,** consulting engineer of New York City, before the New York Section of the Society of Chemical Industry.

Limitations of space in our last issue forced us to withhold several portions of Mr. Clarke's paper. These are herewith reported.

PROGRESS IN DESIGN AND COSTS

Among the interesting details in changes of design made in the course of years, Mr. Clarke mentioned the following:

At first the gas nozzles used to carbon up, impeding the flow of the gas and in consequence making "cold spots." To correct this the nozzles were changed at frequent intervals when they showed signs of carboning, but now the gas is cut off a moment or two before reversing, while the air is left on, and so the carbon is burned out. The pipes connected with a fire brick flue for the supply of gas, have plugs at all their angles, so that the plugs may be taken out and pipes cleaned. Peep holes are put in across the top of the oven at every flue and through these the man in attendance can observe and regulate the condition of the gases burning in the flue.

In years gone by the amount of surplus gas available was guaranteed by the oven builders to be 5000 cu. ft. of gas per ton of coal coked of a B.t.u. value of 500 per cubic foot. When in Chicago the other day Mr. Clarke visited a plant that has been in constant operation twenty-seven months, where the yield of surplus gas was 6250 cu. ft., and the B.t.u. value 590. He is creditably informed there is one plant where the surplus gas runs to 6600 cu. ft. This marked improvement, of course, is only possible where the air is absolutely excluded, as leaks would prevent any such results. This condition reflects the highest credit on the oven designers who have made such allowances for the expansion of the materials employed in construction that they can get such results.

The oven size has gone from a capacity of $4\frac{1}{2}$ tons to $13\frac{1}{2}$ tons of coal. At the present time this seems to be about the standard, although some of the engineers are now advocating $12\frac{1}{2}$-ton ovens. While it varies with different coals, an oven is generally about 17 in. to 22 in. wide, with a taper; this being necessary to facilitate pushing the coke. The height of the oven is about 10 ft. and the length from 35 to 40 ft.

The doors which used to be a flat metal frame with a fire brick insert, causing what were known as "black ends" as the coal in the oven projected beyond the flues, are now made deep like a plug which goes into the oven far enough to hold the coal at the level of the first flue.

The cost of the oven has increased from about $7,500 per oven to nearly $20,000 per oven. This, while seemingly excessive is easily explained by the increased weight of all the material entering into the construction of the ovens and their accessories and the fact that for this amount of money the maintenance and conversion cost has been cut to well below 60 cents per ton of coal coked. Taking as an example coal around $28\frac{1}{2}$ per cent volatile, with the ordinary yields a typical balance sheet for a 100-oven plant of $13\frac{1}{2}$ tons per oven capacity on an 18-hour coking time would be as shown in Table I. making the cost of coke $6,629.52 — $3,064.01 = $3,555.51. With a 70-per cent yield 1236 net tons of coke are obtained from 1766 tons of coal, so that the coke costs $2.88 per ton. That is, the ton of coke is obtained for less than the ton of coal costs, and we have 10,500,000 cu. ft. of available surplus gas on 550 B.t.u. value at 10 cents per 1000 cu. ft. and a uniform coke both physically and chemically, and depreciation and interest taken care of.

TABLE I

Daily Expenditure	
1766 tons of coal, at $3 per ton	$5,298.00
Conversion cost, including depreciation, contingencies and charges of every character	1,059.60
Except interest and administration, 60 cts. per ton; Interest on investment of $2,000,000 at 5 per cent, $100,000.	
22 cents per ton of coke, 1236 × 22	$271.92
	$6,629.52
Receipts	
Tar, 7 gal. per ton of coal, at $2\frac{1}{2}$ cts. per gal	$309.05
Sulphate, 1 per cent, at $60 a ton	1,059.60
Gas, 6000 cu. ft., at 10 cts. per cubic foot	1,059.60
Benzol, $2\frac{1}{4}$ gal., at 14 cts., i.e., 20 cts. less 6 cts. conversion	556.29
Toluol, 0.3 of a gal. at 15 cts. per gallon	79.47
	$3,064.01

At present war prices the fortunate owners of by-product coke ovens selling their benzol at $0.50 per gallon and their toluol at $4.50 a gallon, find their coke costs them nothing and then they earn about $450 per day besides. Free blast-furnace fuel makes for low costs and increased earnings.

When changing from 24-hour coking time the tendency was to reduce the time as low as possible, (and coke was successfully made under 16 hours), but the high heats employed made this practice most dangerous, for neglect at any time would melt the oven, so gradually the heats were brought back until a time was reached which the consensus of opinion deemed to be economically balanced. This time was 18 hours, and the ovens after running for long periods on these heats show no signs of deterioration.

RECOVERY OF TAR AND AMMONIA

In discussing the subject of tar and ammonia recovery, Mr. Clarke pointed out that this has shown the least improvement. In Germany and England the tar recovery is much better than with us. Theoretically our coals should yield more than 7 gal. and ammonia more than 1 per cent.

As the coking time was brought down, the yields of tar and ammonia went with it, and frankly as the coke ovens are principally being run to supply metallurgical coke, this subject has not been given the attention that it deserves. The benzol industry is, with the exception of the Semet-Solvay Company, in its infancy. Plants are being built in practically every coke-oven installation since the war began, and what the result will be after the war, remains to be seen. Logically its first and greatest market will be as motor fuel. The production now of gasoline from crude oil is

Gasoline Produced	Barrels	*Crude Oil Produced*	Barrels
1904	6,920,000	1904	117,100,000
1909	12,900,000	1909	188,200,000
1914	34,915,000	1914	265,800,000
1915	41,600,000	1915	267,400,000

Licenses, Automobile

1905	85,000
1910	400,000
1914	1,253,000
1915	1,750,000
1916	2,225,000

It is interesting to note that while the production of crude oil from 1914 to 1915 advanced only 2,000,000 barrels, gasoline in the same period advanced nearly 7,000,000 barrels.

Assuming the production of the old type ovens at 5 tons of coal per day of twenty-four hours, and the larger ovens at 15 tons, and getting a yield of two and a half gallons of 50 per cent benzol per ton, we find the benzol

production to be 85,990,000 gallons or 2,694,000 barrels per annum. Fear has been expressed that after the war the sudden dumping on our markets of 85,000,000 gallons of motor fuel would break the price badly and make a number of lean years for the coke oven benzol producers.

"Without desiring to join the ranks of Ford advertisers, I should like to call one thing to your attention. If 200,000 of the 300,000 Ford cars produced annually remain in this country and have an average mileage of 5000 miles per car and consume a gallon of gasoline for every fifteen miles, the annual consumption will be 66,666,000 gallons. Since the benzol output if all sold for motor spirits only amounts to 84,990,000 and one make of car uses 66,000,000 with the increase in automobile production that the statistics above show, it seems to me we are fortunate that we have a new fuel coming on the market."

The production of tar in gallons in 1905 was 36,379,000, in 1910 it was 69,780,000 gallons, and when the various plants now built and building are in operation, these figures will advance to 237,947,000 gallons of tar. Sulphate of ammonia productions in 1905 in the United States was 65,000 tons of 2000 lb., in 1910 it was 115,000 tons. When the present ovens now built and building are operating, the production will be about 340,000 tons. The price of these commodities has been 2½ cents per gallon for the tar and for the sulphate of ammonia around $60 a ton for the past ten years.

Mr. Clarke then gave what appears to be the most up-to-date list of by-product coke ovens built or in course of construction in the United States. (Table II.)

TABLE II—LIST OF BY-PRODUCT COKE OVENS OF THE UNITED STATES NOW BUILT AND IN COURSE OF CONSTRUCTION

	Type	No.	Benzol
American Steel Wire Co., Cleveland, Ohio	Koppers	180	Yes
Allegheny By-Products Coke Co., Glassport, Pa.	Otto	120	Yes
Buffalo Union Fee. Co., Buffalo, N. Y.	Roberts	60	Yes
Brier Hill Steel Co., Youngstown, Ohio	Koppers	84	Yes
By-Product Coke Corp., South Chicago, Ill.	Semet S	280	Yes
Cambria Steel Co., Johnstown, Pa	Otto	372	Yes
Cambria Steel Co., Johnstown, Pa	Koppers	92	Yes
Central Indiana Gas Co., Muncie, Ind	Klome	22	?
Citizens' Gas Co., Indianapolis, Ind	Otto	100	Yes
Coal Products Co., Joliet, Ill	Koppers	35	Yes
Coal Products Co., Joliet, Ill	Wilputte	18	Yes
Central Iron & Steel Co., Tuscaloosa, Ala.	Semet S	60	Yes
Cleveland Furnace Co., Cleveland, Ohio	Semet S	100	Yes
Chattanooga Gas Co., Chattanooga, Tenn.	Roberts	12	?
Carnegie Steel Co., Clairton, Pa	Koppers	640	Yes
Colorado Fuel & Iron Co., Pueblo, Col	Koppers	120	Yes
Empire Coke Co., Severa, N. Y	Semet S	46	Yes
Gulf State Steel Co., Gadsden, Ala	Koppers	37	Yes
M. A. Hanna & Co., (Dover By-Product Coke Co.), Canal Dover	Roberts	24	Yes
Inland Steel Co., South Chicago, Ill	Koppers	86	Yes
Inland Steel Co., South Chicago, Ill	Koppers	44	Yes
Indiana Coke & Gas Co., Terre Haute, Ind.	Gas Machine	30	Yes
Indiana Steel Co., Gary, Ind	Koppers	560	Yes
Illinois Steel Co., Joliet, Ill	Koppers	280	Yes
Kentucky Solvay Co., Ashland, Ky	Semet S	108	Yes
Lehigh Coke Co., South Bethlehem, Pa.	Didier	40	Yes
Lehigh Coke Co., South Bethlehem, Pa.	Koppers	424	Yes
Laclede Gas Light Co., St. Louis, Mo	Koppers	56	Yes
Labelle Iron Works, Follansbee, W. Va.	Koppers	94	Yes
Lackawanna Steel Co., Buffalo, N. Y	Otto	188	Yes
Lackawanna Steel Co., Buffalo, N. Y	Rothberg	280	Yes
Lackawanna Iron & Steel Co., Buffalo, N. Y.	Otto	232	Yes
Maryland Steel Co., Sparrows Point, Md.	Koppers	120	Yes
Minnesota Steel Co., Duluth, Minn	Koppers	90	Yes
Michigan Alkali Co., Wyandotte, Mich	Semet S	30	Yes
Milwaukee Coke & Gas Co., Milwaukee, Wis.	Semet S.	160	Yes
New England Gas & Coke Co., Everette, Mass.	Otto	400	?
National Tube Works, Benwood, W. Va.	Semet S	120	Yes
Niagara Coke Corp., Buffalo, N. Y	Otto	100	Yes
Northwestern Iron Co., Mayville, Wis	Otto	72	Yes
North Shore Gas Co., Waukegan, Ill	Semet S	13	No
Pennsylvania Steel Co., Lebanon, Pa	Semet S	120	Yes
Pennsylvania Steel Co., Steelton, Pa	Semet S	40	Yes
Philadelphia Suburban Gas & E. Co., Chester, Pa.	Semet	40	Yes
River Furnace Co., Cleveland, Ohio	Koppers	204	Yes
Republic Iron & Steel Co., Youngstown, Ohio	Koppers	143	Yes
Semet-Solvay Co., Dunbar, Pa	Semet S	110	Yes
Solvay Process Co., Delray, Mich	Semet S	175	Yes
Solvay Process Co., Syracuse, N. Y	Semet S.	40	Yes
Sharon Coke Co., Sharon, Pa	Otto	212	Yes
South Jersey C. E. & T. Co., Camden, N. J.	Otto	150	Yes
South Jersey C. E. & T. Co., Camden, N. J.	Koppers	45	Yes
Seattle Lighting Co., Seattle, Wash	Klonne	22	Yes
Seaboard By-Product Coke Co., Jersey City, N. J.	Koppers	110	Yes
Tennessee Coal & Iron Co., Ensley, Ala.	Semet S	240	Yes
Tennessee Coal & Iron Co., Fairfield, Ala.	Koppers	280	Yes
Toledo Furnace Co., Toledo, Ohio	Koppers	94	Yes
United States Furnace Co., Canton, Ohio	Koppers	47	Yes
Western States Coke Co., St. Paul, Minn.	Koppers	55	Yes
Woodward Iron & Steel Co., Woodward, Ala.	Koppers	170	Yes
Youngstown Sheet & Tube Co., Youngstown, Ohio	Koppers	204	Yes
Zenith Furnace Co., Duluth, Minn	Otto	65	Yes

COMPARISON OF AMERICAN AND EUROPEAN PRACTICE

Mr. Clarke then stated that two years ago he visited most of the by-product coke ovens in the Durham and Middlesborough district in England, and a great many of the ovens in the triangle formed by Düsseldorf, Dortmund and Wesel, which is the lower Rhine Westphalian steel district. After having seen just before he left the practice and mechanical refinements of the Gary plant, visiting the coke oven operations in Europe brought back very vividly to him the American practice of ten years ago, and "one realized how entirely we had gotten away from the old world's standard."

There were only two things that he saw where he considered Europe was in advance of us. One was a gas engine installation, and the other in the use of mixed gases. At one of the big German steel plants they have a 10,000-hp. installation of gas engines, generating electricity which cost them complete $300,000. That same installation over here would have cost $1,000,000, which may explain why the large gas engine unit is less in vogue here than there.

The other instance was at Skinningrove, where Mr. Ernest Bury, who has contributed liberally to coke oven data, in a number of papers he has presented before various bodies in England, took the visitors through his plant, where he was using a mixture of three voulmes of blast-furnace gas with one volume of coke-oven gas, and getting a mixture about as follows: hydrogen 13.25, methane 0.75, unsaturated hydrocarbons 0.5, carbon monoxide 22.75, carbon dioxide 9., nitrogen 47., B. T. U. per cubic foot 206. He was using this gas in his gas engine to produce electricity; also in the open-hearth furnaces and in the soaking pits. These gases replaced producer gas of analysis running in hydrogen from 9. to 14. methane 2. to 3.5, carbon monoxide 22.28, carbon dioxide 3. to 6., nitrogen 55. to 60., B.t.u. 125. to 175. "That we will come to use a mixture of this kind I am confident, especially as natural gas, which has been so instrumental in building up the steel industry in Pennsylvania, is rapidly beginning to show signs that it cannot be counted on in the future as it has been in the past."

The advantage of the use of these gases is that a constant supply of uniform composition and calorific value is always available. In the case of melting furnaces the cost per ton of ingot is less than that of producer gas, and there is no standby loss. No space is needed for fuel storage. There are no labor repair costs, and constant supervision, in order to procure producer efficiency is eliminated. In good blast-furnace practice, where the gases are efficiently washed they are using about 30 per cent of the total volume of the gas for stoves, 7.5 per cent for the boilers, and 12.5 per cent for blowing engines, and there is a 5 per cent loss in washing, etc., leaving a surplus of available gas of from 40 to 45 per cent. This gas has a value of between 90 and 100 B. T. U's. The volume of gas depends, of course, on the amount of air that is being blown and what the charge is, but will amount in the case of a modern furnace to around 25,000,000 to 30,000,000 cubic feet per day per furnace.

By mixing this low-B. T. U. value gas with the richer coke oven gas, making an average of 200 to 250 B. T. U.'s per cu. ft. mixture, an increased supply of calorifically uniform fuel gas is obtained, which undoubtedly is advantageous.

"With the exception of these two things, I can truthfully say that the European practice, excepting in ammonia and tar yields, is in no way comparable to the present United States practice, and in engineering and amount of production we are immeasurably superior to our instructors."

In the conclusion Mr. Clarke pointed out that the changes which are occurring from day to day in the American by-product industry are so numerous and may be so important that "one cannot help feeling that two years from now everything said tonight will be obsolete, excepting for the two principles involved, uniformity in the coke and regularity in the operation and in the temperature of the ovens."

Capacity and Economy of Multiple Evaporators

Professor **E. W. Kerr,** of Louisiana State University and A. & M. College of Baton Rouge, La., has contributed in the past to the profession a series of valuable papers on evaporators and vacuum pans, and their performance with special reference to sugar-house practice (see our Vol. XI, pages 333 and 611, 1913, and Vol. XIII, pages 485 and 551, 1915).

At the recent meeting of the American Society of Mechanical Engineers in New Orleans Professor Kerr presented another interesting paper on the "Capacity and Economy of Multiple Evaporators." An abstract of this paper is herewith given.

The process of evaporating in sugar-factory work consists of two distinct parts: First, the juice with a density of 12 deg. to 18 deg. Brix is concentrated by evaporating off part of its water to approximately 55 deg. Brix in a multiple evaporator; second, the syrup produced is then taken to a vacuum pan working single effect, and where further water is removed by evaporation under conditions suitable for crystallizing the sugar, the final density being in the neighborhood of 95 deg. Brix.

Professor Kerr's present paper deals with the first part of the process, namely, the evaporation in multiple effect. The capacity of multiple-effect evaporators depends on two general factors: the coefficient of heat transmission and the temperature fall from one effect to the next effect.

The **coefficient of heat transmission** depends on the following nine factors:

1. (*a*) Steam distribution, (*b*) steam velocity.
2. Density of heating steam.
3. Quality of heating steam (whether superheated or not).
4. Presence of air or other incondensable gases in the steam, which may be expressed mathematically by the ratio $P_a \div P_t$.
5. Presence of condensation on the heating surface.
6. Cleanliness of heating surface (steam side).
7. Material, thickness and molecular structure of tubes.
8. Cleanliness of heating surface (liquor side).
9. Velocity of liquor circulation.

The heat transmitted from steam through a metal wall to a liquid being boiled takes place in three steps: First, from the steam to the initial surface of the metal (this is affected by the above items 1 to 6); second, from the initial surface through the metal wall to the cooler surface (item 7); third, from the cooler surface to the liquid being boiled (items 8 and 9).

The **temperature fall** depends on the following six factors:

10. Pressure of steam supplied to first body.
11. Vacuum in last body.
12. Hydrostatic head (height of boiling).
13. Presence of air or other incondensable gases in the steam (see item 4 above).
14. Density of liquor being boiled.
15. Purity of liquor being boiled.

Factors Affecting Heat Transmission

DENSITY OF HEATING STEAM

Although in many respects evaporators are similar to surface condensers, there are certain fundamental differences. In surface condensers, the density of the heating steam varies between very small limits, corresponding to vacuums of, say, 24 to 29 in., whereas in evaporators the steam pressure varies from about 5 lb. per square inch gage in the first body to a vacuum of about 15 in. in the last body, with corresponding variations in density.

In surface condensers, air is the only incondensable gas, and it enters with the steam, also by leakage through joints and metal pores; in evaporators, other incondensable gases, such as ammonia, sulphur fumes, etc., entering with the juice, have to be contended with. Evaporator shells also furnish larger areas in contact with the atmosphere per unit of capacity than do surface condensers, thus increasing the danger of air leakage.

In surface condensers, the danger of scale or other fouling of tubes is confined mainly to the steam side, the high velocity of the cooling water preventing any fouling on the other, even with bad water; in evaporators, however, the larger part of the fouling is on the liquor side. The tendency to fouling depends on the condition of the juice as to density, materials used in clarification, etc.

In surface condensers the velocity of the cooling water is produced by a pump or other mechanical means, whereas in evaporators the circulation is produced by convection and steam currents.

In surface condensers the factors hydrostatic head, density of liquid and purity of liquid do not enter, whereas they are important in connection with evaporators.

QUALITY OF HEATING STEAM (WHETHER SUPERHEATED OR NOT)

The effect of superheat in steam on the coëfficient of heat transmission is not very well known, the results of different experimenters being more or less contradictory. The author's experiments seem to show that superheat does not affect the coefficient of heat transmission, and results by other recent experimenters substantiate this.

Operators, on the other hand, frequently state that greater capacity can be obtained with exhaust steam than with live steam. Most evaporators are arranged to use live steam in case the exhaust steam supply is insufficient; boiler steam is throttled down to the necessary low pressure, resulting in superheating the steam, and the importance of the matter lies in this. Professor Kerr concludes that in all probability the apparent reduction in capacity noticed with the use of live steam is due to the live steam pipe being too small to supply steam to the evaporator at a pressure equal to that in the exhaust main.

PRESENCE OF AIR AND OTHER INCONDENSABLE GASES IN THE STEAM

The presence of air and other incondensable gases is doubtless one of the most fruitful causes of low heat

transmission. It is probable also that less is known about this factor than any other involved. Air-free steam is practically impossible, and, as stated, the conditions in this respect are less favorable in evaporators than in surface condensers.

As the result of a large number of experiments on surface condensers, George A. Orrok states that the heat transmission coefficient varies according to the expression $(P_s \div P_t)^2$, in which P_s represents the partial steam pressure and P_t the total pressure of steam and air combined. Experiments by Professor Kerr on laboratory evaporators seem to show that the exponent in the above expression lies somewhere between 3 and 4.

A considerable amount of experimenting on this subject has been done recently by Professor Kerr. Temperatures were measured at different portions of a laboratory calandria on the basis that the greater the amount of air in any locality of the steam compartment, the lower the temperature there. Typical results are given in the paper. The thermometers were inserted through the shell at points indicated in the table, and were made to extend a few inches into the steam compartment. The figures show very clearly that there was considerable variation of temperature in different parts of the calandria, and also a shifting of temperatures. Some temperatures were found higher than the saturation temperature and some lower; the former were due to superheat and the latter to the presence of air.

These data seem to show that there are air pockets, changing from place to place; also that there is practically the same temperature at all points when the evaporator is boiling at a high rate, the velocity of steam being much greater in this case.

The prevention of these air pockets is a matter for the consideration of designers. It seems reasonable to expect that air pockets will form in dead spaces, *i.e.*, where there is little or no movement of steam, and for this reason good distribution is very important. High velocities produced by means of baffles, etc., should result in the prevention of air pockets.

In practice some of the air is removed by means of the condensation pumps which draw from the bottom of the steam compartment, and some is vented from the top through small openings connected either to the next body or direct to the condenser. This statement applies particularly to the more common types—vertical juice-tube evaporators and horizontal steam-tube evaporators. Other special types make use of various devices, in some cases each tube having its individual vent. In some types the vents can be controlled, while in others they cannot.

One of the great difficulties is the impossibility of removing the incondensable gases without removing steam along with them and reducing the economy.

In addition to its insulating effect, air in the steam reduces heat transmission by causing a temperature fall lower than the apparent fall. This is because the temperature of the heating steam is lower than the saturation temperature corresponding to the pressure.

CONDENSATION ON THE HEATING SURFACE

The loss in capacity due to the presence of condensation on the heating tubes depends upon the type and design of evaporator. The bottom portions of long vertical tubes will be affected more than those of shorter ones. In vertical juice-tube evaporators the water, after reaching the lower tube sheet, must zigzag among the tubes to reach the outlet. Tube sheets are inclined by some makers to facilitate the removal of condensation. Occasionally the tubes themselves are inclined so that the condensation runs along the underside of the tube in attenuated form to the bottom, the idea being to reduce the amount of surface in contact with the water. The removal of water is also facilitated by using multiple outlets, reducing the distance the water has to travel along the bottom tube sheet. In horizontal steam-tube evaporators, the condensation gravitates to the lower side of the tube and is blown through by the steam.

CLEANLINESS OF HEATING SURFACE ON THE STEAM SIDE

The fouling of the heating surface on the steam side is mainly due to oil in the exhaust steam coming from the engines. An oil separator in the supply pipe to the evaporator aids in overcoming this difficulty, and when steam turbines are used as prime movers the difficulty is avoided.

In vertical juice-tube evaporators there is little opportunity for cleaning the oil scale from tubes, as the latter are difficult of access. A very efficient means of cleaning them is to fill the steam compartment with molasses during the off-season; the acid in the molasses attacks the scale and removes it.

Steam-tube evaporators have the advantage that mechanical cleaning by means of swabs is possible. This can be done with the tubes in place. Tubes in this type are usually removable, however, and this facilitates cleaning.

MATERIAL, THICKNESS AND STRUCTURE OF TUBES

Evaporator tubes are generally made of copper or brass, more often the former. The thickness is usually about 1/16 in., ranging from 14 to 18 B.W.G. Within this range of thickness the variation in the coefficient of heat transmission is practically negligible. In standard evaporators the most common size is 2 in. diameter by 48 in. long. Steam tubes are usually of smaller diameter and much longer, a common size being 3/4 in. diameter by 12 ft. to 14 ft. long.

CLEANLINESS OF HEATING SURFACE ON LIQUOR SIDE

The fouling of tubes on the liquor side presents a difficult problem. The rapidity with which scale forms depends upon several factors, such as method of clarification used, amount of lime used, quantity of gums remaining in the juice after clarification, velocity of juice circulation, etc. This scale collects on the inside of juice tubes and on the outside of steam tubes. It can be removed by filling the juice compartment with a solution of soda or hydrochloric acid and boiling; it is generally necessary to do this about once a week. The juice scale is usually worse in the last bodies on account of the increased density of the juice.

Makers of some special types of evaporators claim for them that the juice scale can be removed by reversing the flow of vapors. The cool body is thus made the hot body, and expansion of the metal of the tubes cracks the scale.

A very convenient way to clean the tubes of standard horizontal evaporators is to remove them and crack the scale by mechanical means.

VELOCITY OF LIQUOR CIRCULATION

Rapid juice circulation is also a factor in securing efficient heat transmission. The heat transmitted through the tube walls produces vapor bubbles which tend to collect on the surface of the tube, and in turn prevent heat transmission. A rapid circulation brushes these bubbles away and increases the number of contacts between the cooler surface and the liquid. As stated, circulation is produced in evaporators by convection and steam currents, except in a few special types. In vertical juice-tube evaporators the velocity varies with the

proportions of the tubes; that is, with the ratio of the heating surface per tube divided by the carrying area of the tube.

A matter of considerable importance is that of entraining or priming. Vertical juice tubes especially are likely to *spout* if they are forced too hard. This can be overcome, however, by the use of baffles in the vapor space and by means of separators in the vapor pipes. The circulation in horizontal evaporators is less rapid and not so well defined as in vertical evaporators having usually a central downtake or circulation tube.

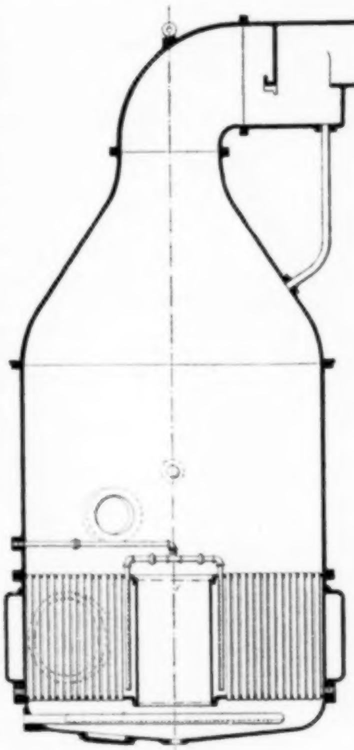


FIG. 1—ONE BODY OF VERTICAL SUBMERGED TUBE EVAPORATOR WITH BELT STEAM DISTRIBUTION (TYPE A)

Factors Affecting Temperature Fall

STEAM PRESSURE IN FIRST BODY AND VACUUM IN LAST BODY

Important among the factors affecting temperature fall are initial steam pressure and vacuum in last body. The former is limited, 5-lb. gage being an average, with 10 lb. the maximum. If sugar juice is boiled at a temperature above 220 to 230 deg. Fahr. there is danger of injuring the sugar. High pressure also reduces the capacity of the mill and other engines due to the high back pressure.

The vacuum in the last body is generally about 26 in. With 10 lb. initial steam pressure this would give a total temperature fall of 114 deg., and a pressure of 5 lb. would give a total fall of 102 deg., which must be divided among the several bodies of a multiple effect. This means greater temperature fall and capacity per unit of heating surface in a triple than in a quadruple, and still more in a double. Simple calculations will show that a decrease of pressure at the condenser end will increase the total temperature fall much more than will an equal increase of initial pressure.

Some have contended that high vacuum is desirable, and it is not uncommon to specify a vacuum of 27 in. for evaporator installments. It is doubtful, however, if a vacuum higher than 26 in. is desirable, especially in submerged tube evaporators which operate with considerable hydrostatic head.

HYDROSTATIC HEAD

Hydrostatic head (submergence of the heating surface) decreases heat transmission by increasing the temperature at which the liquor boils. This makes the temperature fall less than that obtained by subtracting the temperature corresponding to the vapor pressure from the temperature of the steam in the calandria (apparent temperature fall). This loss varies in the different bodies inversely with the absolute pressure of boiling; that is, with a given height of boiling the loss will be greatest in the last body and proportionately less in preceding bodies. The original paper gives the loss due to hydrostatic head for the three bodies of a triple effect with apparent temperature falls of 20 deg., 30 deg., and 50 deg. respectively in the first, second, and third bodies, with heads varying from 0 to 48 in. Developments in evaporator design have been largely affected by this question. The loss due to hydrostatic head is greatest in vertical submerged tube evaporators, and is less in horizontal steam tube evaporators, while film evaporators avoid it entirely. In view of the large loss due to this cause when the absolute pressure is very low, film evaporators can make better use of high vacuum in the last body than can submerged tube evaporators.

DENSITY AND PURITY OF LIQUOR

High density of the liquor being boiled causes reduced heat transmission by making the actual temperature fall lower than the apparent fall.

This loss is still greater with sugar solutions of low purity. For example, in a sugar solution with a density of 70 deg. Brix and a purity of 100 per cent, the boiling temperature is about 12.5 deg. above the saturation temperature of steam, whereas with the same density and a purity of 60 per cent the tempefature of boiling is approximately 18.5 deg. above the saturation temperature of steam.

Tests of Evaporators in Sugar Factories

The second part of Professor Kerr's paper gives the results of tests of evaporators of commercial size and under regular operating conditions in sugar factories.

Observations were made of practically all factors which might affect the results. A typical log included observations of the pressure or vacuum in the steam or vapor space of each body; temperature and density of the juice entering and leaving; weight of juice entering and leaving; weight of condensed steam from the first body, etc. Concerning details of the measurements and calculations employed, the reader must be referred to the complete paper. We give only the results.

The evaporators tested included double, triple, and quadruple effects of the following types:

(A) Vertical submerged tube (so-called standard, Fig. 1).

(B) Horizontal steam tube (Figs. 2a and 2b).

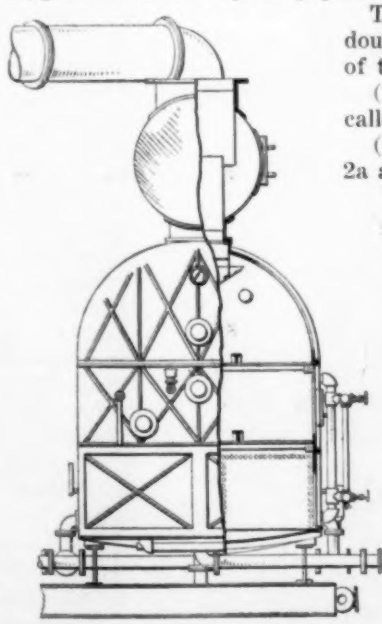


FIG. 2A — ELEVATION OF HORIZONTAL EVAPORATOR (TYPE B)

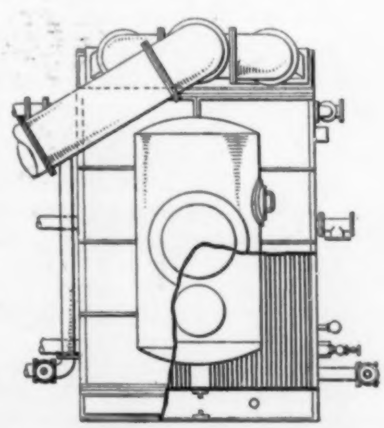


FIG. 2B—PLAN VIEW OF EVAPORATOR, FIG. 2A

(C) Horizontal film evaporator, as illustrated in Fig. 3 diagramatically.

(D) Vertical film evaporator, as illustrated diagramatically in Fig. 4.

(E) Standard type with special baffle steam distribution, running under vacuum (illustrated in Fig. 5, page 607).

(F) Same as E, but with atmospheric pressure in last body, no vacuum apparatus being used.

(G) Vertical steam tubes with special means for venting each tube (double tube, illustrated in Fig. 6, page 607).

Types A and B (Figs. 1 and 2) are so familiar that it is not necessary to describe them. The majority of the sugar house evaporators used in practice belong to one or the other of these two general types.

In type C, Fig. 3, the horizontal tubes are expanded at one end into a thick tube plate, and at the other are closed except for a small vent which releases the incondensable gases into the vapor space. The water of condensation leaves the tube at the end where the steam enters. Juice is supplied by centrifugal pumps to a distributor above the tubes and falls in a film from one tube to another. The piping is such that the juice may be recirculated over the tubes until the desired concentration in each body is obtained.

In the vertical film type D, Fig. 4, the juice level is near the bottom of the tubes, the latter being approximately 20 ft. long. A rapid current of steam rising through the tubes sweeps juice along with it. The pressure of the steam on the interior of the tube keeps this juice as a film (often referred to as *climbing film*) on the tube surface. The juice, thus projected upward, on issuing from the tops of the tubes enters a special separator which separates it from the vapor. The juice and vapor then pass from body to body in the usual manner.

In interpreting the results of tests of evaporators it is of utmost importance to take into consideration that the conditions of operation are often very different. Some important differences of practice may be stated as follows:

The **removal of condensation** from the steam compartments may be effected by:

(*a*) Pumps from each body.

(*b*) Siphoning the condensation from body to body, a pump being used to remove it from the last body.

(*c*) Barometric leg pipe; this method can be used only in case the evaporator is high enough to give a column of water sufficient to balance the vacuum in the space being drained.

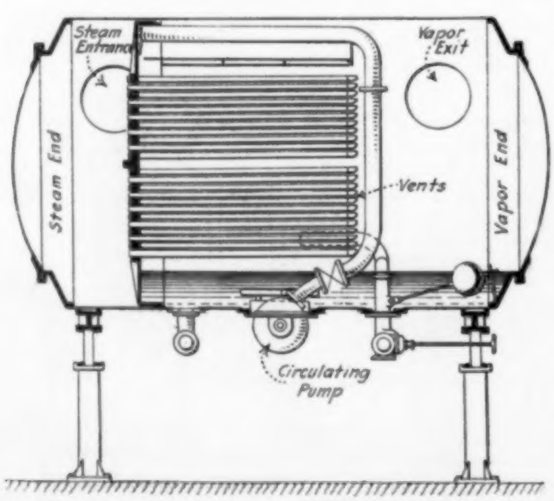


FIG. 3—ONE BODY OF TYPE C EVAPORATOR

The **venting of incondensable gases** may be effected by:

(*a*) Small pipes tapped through the shell just under the top tube sheet.

(*b*) Small pipes tapped into the top tube sheet and located near the downtake. Usually two or four of these tubes are used, which are connected together inside of the vapor space with a single pipe brought through the shell and a valve placed on the outside for control.

(*c*) In horizontal evaporators, the steam chest opposite the steam entrance is vented.

(*d*) Special methods depending on the type of evaporator.

In all of the above the vented gases may be taken direct to the condenser or to the next body, though so far as heat transmission is concerned, it is doubtless better to vent direct to the condenser. Usually valves are placed in vent lines in order that control may be exercised. In some cases the venting is continuous and in other cases intermittent, depending upon the ideas of the operator. In types C and G special means of venting are used which have been explained above.

Finally, the condition of the heating surface (whether freshly cleaned or not) is naturally of greatest importance for the performance of an evaporator.

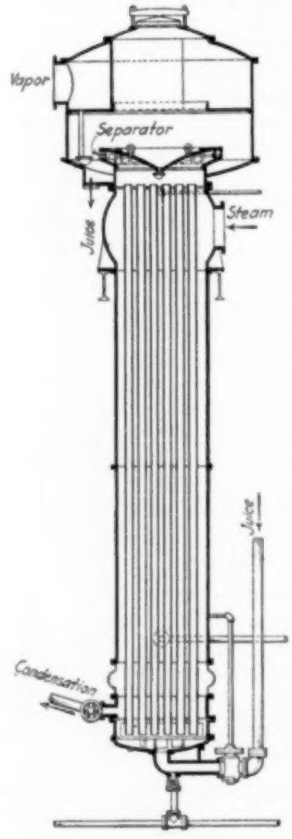


FIG. 4—ONE BODY OF TYPE D EVAPORATOR

Fig 7 is a graphical log of a typical test of Professor Kerr. The complete figures for the different tests are given in form of tables in the original paper.

DEFINITIONS

It is customary to make exaporator guarantees on a basis of 75 per cent evaporation by volume. As the initial and final densities of the juice are seldom such as to give exactly 75 per cent evaporation, it is necessary to determine the "equivalent volume of juice in gallons per 24 hr." by calculation. There seems to be no standard unit for rating evaporators. Sometimes an evaporator is guarnateed to handle a stated number of gallons of juice per 24 hr. with 75 per cent evaporation, nothing being stated as to the temperature of the juice; in other cases the temperature of the juice is specified. Probably the best standard rating would be "*equivalent gallons of juice handled per* 24 *hr. with* 75 *per cent evaporation.*" Primarily a multiple evaporator is supposed to evaporate and not heat; actually, however, the juice may enter the first body at a temperature lower or higher than that of boiling.

The method of calculating the "equivalent juice treated with 75 per cent evaporation" is illustrated by a numerical example in the original paper.

The term *thermal efficiency* is used to indicate the heat efficiency of the evaporator as a whole. It may be

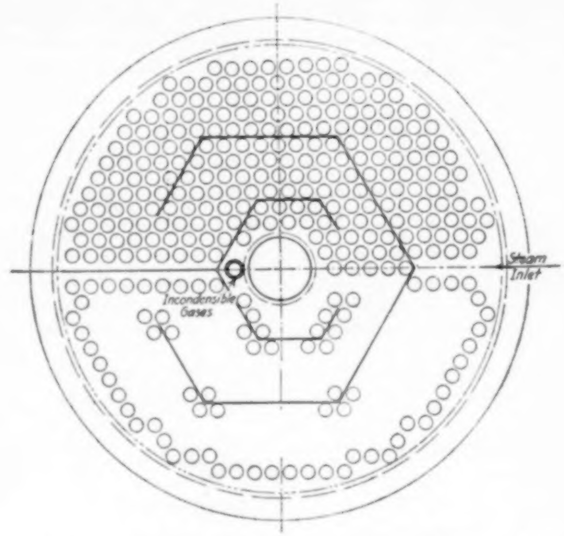


FIG. 5—STEAM DISTRIBUTION (TYPES E AND F EVAPORATORS)

determined by dividing the actual weight of water evaporated per pound of steam supplied by the theoretical weight of water that would be evaporated per pound of steam supplied were there no heat losses. The method of calculating the thermal efficiency is illustrated in Professor Kerr's paper by a numerical example.

HEAT TRANSMISSION TESTS

The coefficient of heat transmission, the B.t.u. transmitted per square foot of heating surface per hour per degree difference in temperature, is obtained for each body by dividing the heat in British thermal units transmitted during the test by the number of hours, by the number of square feet of heating surface and by the apparent temperature fall in that body. As the apparent temperature fall is used, the coefficients are termed "apparent."

The results are given in the paper in tables and diagrams. In general, the heat transmission coefficients of the evaporators in actual sugar-house practice were found to be smaller than the coefficients in former determinations in laboratory tests. This is doubtless due among other things to the fact that the heating surface in the laboratory apparatus was always clean, while in the sugar houses the tests were made in nearly all cases without special preparation, the time since cleaning, etc., varying considerably. It is interesting to note, however, that the coefficients obtained are higher than with ordinary surface condensers and equally as high as with modern types of high-vacuum surface condensers.

Typical curves are given in the paper for the heat transmission coefficients of the different types and comparative curves for types A, B, C and D evaporators are reproduced in Fig. 8.

Table I gives the average, maximum and minimum coefficients for each type taken from the same tests. The highest actual coefficients were obtained from type F (atmospheric double effect). These high coefficients were doubtless due to the high steam pressure and the corresponding high density of the steam. As *apparent* temperature fall was used in determining the coefficients, they not only indicate the relative heat transmitting ability of the heating surface in the different types, but include also the effect of peculiarities due to type, such as hydrostatic head, method of removing condensation, method of venting, etc. The film evaporators (types C and D) gave coefficients considerably higher than did the submerged tube types.

TABLE I—COEFFICIENT OF HEAT TRANSMISSION (Actual)

Type	Average	Maximum	Minimum	No. of Tests Included in Average	Relative Coefficient (Actual) Standard = 100	Relative Coefficient (Corrected) Standard = 100
A	197	289	172	7	100	100
B	213	291	130	5	108	74
C	392	449	334	3	199	160
D	266	353	190	6	135	119
E	248	284	190	3	126	180
F	503	509	498	2	255	131
G	293	...	...	1	149	139

Comparing types A and B, the latter has some advantage, the average actual coefficient for type B being some 8 per cent greater than the average for type A. The tests of type E show an average coefficient of 248, which is some 25 per cent greater than the average for type A. Comparing types C and D the average coefficient for the former is 392, which is some 47 per cent greater than that of the latter. Type C requires centrifugal circulating pumps for handling the juice, something not required by other types. Tests of motors driving these pumps showed 0.1 hp. per 1000 gal. of juice treated per 24 hr. This should be kept in mind in comparing this type with others. Only one test was made upon type G and this under conditions which could hardly be called favorable, the amount of juice supplied being far below its rated capacity and the juice head greater than would have been used had it been operated with an amount of juice nearer its normal capacity.

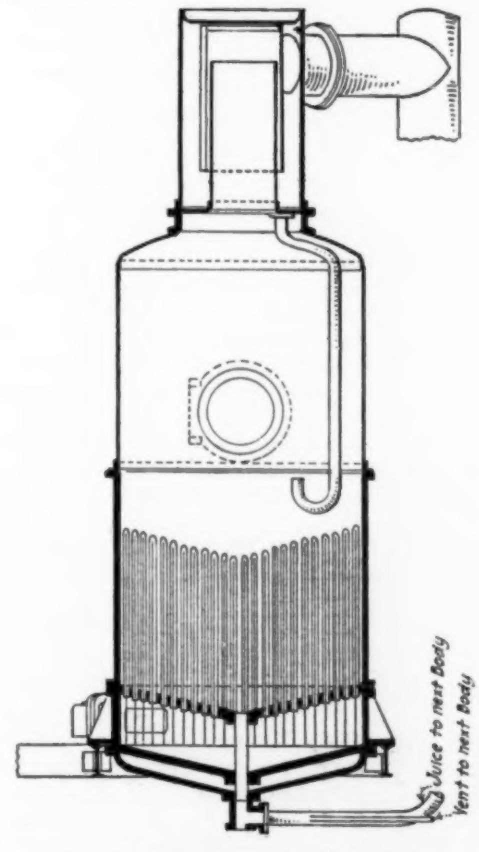


FIG. 6—DOUBLE TUBE EVAPORATOR (TYPE G)

With type A only four evaporators out of a total of eleven gave coefficients above 200. In these four the conditions of operation were fair as regards cleanliness, drainage and venting. The number of days since clean-

ing is given for each test, though this can hardly be relied upon to give an accurate idea of the condition of the heating surface, for the reason that all of the evaporators had not been cleaned with equal thoroughness. In practice, the time consumed in boiling out, also the strength of the soda and acid, vary greatly. In some cases, the thoroughness of cleaning is not sufficient to prevent a progressive fouling of the heating surface toward the end of the season.

Practically all of the tests on type A were made with very low steam pressure in the first body, usually near atmospheric pressure, and in some cases, less than atmospheric pressure. With most of the other types, the pressure was higher, which puts type A at a disadvantage in making comparisons with the average coefficients given. On the basis of laboratory tests a correction was made and the *corrected* coefficients are given in the last column of Table 1. These *corrected* coefficients may perhaps give a better means of comparing types than the actual coefficients, especially as regards types A and B. However, too much dependence should not be placed on these corrected coefficients, as the correction formula was determined from laboratory experiments.

RATE OF EVAPORATION

The unit "pounds of water evaporated per square foot of heating surface per hour" is convenient for rating evaporators, and is fairly satisfactory provided the steam pressure and the vacuum do not vary greatly. The *actual* values do not furnish a fair comparison on account of the widely varying steam pressure and vacuum. An attempt has been made by the author to determine the equivalent evaporation that would have resulted had all tests been made with a steam pressure of 5 lb. gage in the first body and a vacuum of 26 in. in the last body.

These corrected values for the average pounds of water evaporated per square foot of heating surface per hour are for type A quadruple 6.18, A triple 9.2, A

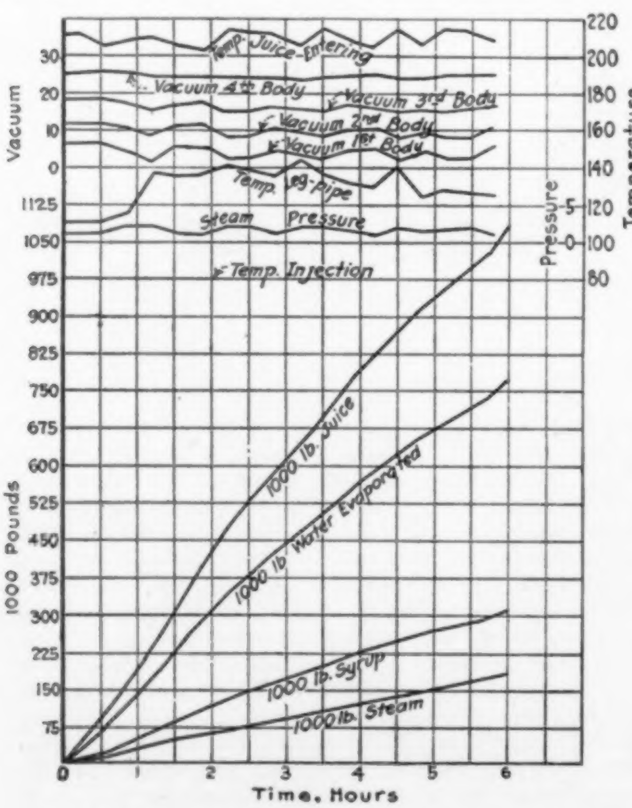


FIG. 7—GRAPHICAL LOG OF TYPICAL EVAPORATOR TEST

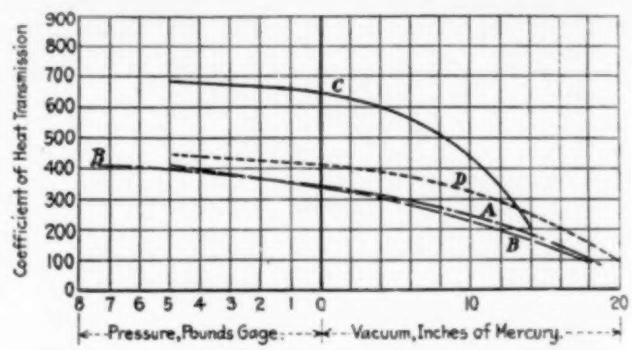


FIG. 8—COMPARISON OF HEAT TRANSMISSION COEFFICIENTS, TYPES A, B, C AND D EVAPORATORS

double 16.7, B quadruple 4.55, B triple 11.49, C quadruple 11.05, D quadruple 10.05, D triple 9.21, E triple 16.93, F double 17.4, and G quadruple 9.67.

THERMAL EFFICIENCY

Figures for "thermal efficiency" are finally given by Professor Kerr, after discussing losses due to radiation, losses due to vents, the effect of the method of handling the condensed steam (method *b* of those enumerated on page 606 being considered the most economical), etc.

The figures for thermal efficiency vary from a minimum of 85.06 to 98.3, the average being 94 per cent. The table in the original paper of Professor Kerr shows that the efficiency of type C was higher than type D, although the water evaporated per pound of steam supplied was greater in the latter than in the former. This apparent contradiction is due to two things: (1) the temperature of the juice entering the first body in the tests on type D was higher than in those on type C, more steam being required for heating in type C; (2) the condensation in type D was taken from body to body, beginning with the second, whereas it was drained away separately from each body of type C.

The table also emphasizes the importance of heat insulation and the effect of high rates of evaporation in increasing heat efficiency.

Recent Chemical and Metallurgical Patents

Iron and Steel

Cooling Exhaust End of Open-Hearth Furnace.—An arrangement of an open-hearth furnace designed to lengthen the life of the furnace ends by cooling them when subject to the action of the hot exhaust gases is patented by REGNIER EICKWORTH of Dortmund, Germany. Channels are arranged in the crowns of the furnace ends and connected with a compressed air conduit. The compressed air cools the crown, and passing into the exhaust channels a cooling effect results there. In order that the compressed air shall pass into the exhaust gases both ends of the furnace must be provided with channels and connected to a common compressed air line, which has a reversing valve at the junction. When the furnace gases are reversed the compressed air is reversed, the air-reversing gear being preferably connected to the furnace-reversing gear. The inlet end of the furnace thus does not receive any cooling. (1,176,-744, March 28, 1916.)

Electrolytic Iron from Pyrite.—Sulphide ores of iron have not had commercial importance as sources of metallic iron, but have been treated mainly for the production of sulphurous and sulphuric acid, or for such other precious or base metals as the ores may contain.

The subject of a patent granted to AXEL ESTELLE of Hagen, Westphalia, Germany, is the treatment of pyritic iron ores for the production of electrolytic iron and pure sulphur. The process consists in first leaching the raw ore with weak non-oxidizing acid and precipitating the iron electrolytically with insoluble electrodes, a suitable method being employed for regenerating the solution. The steps of the process are shown in Fig. 1. Pyrite is first subjected to distillation without access of air, as in an electric furnace, for the sublimation and recovery of sulphur; or a smelting process may be conducted to render the iron in acid-soluble form and at the same time recover any valuable metals contained in

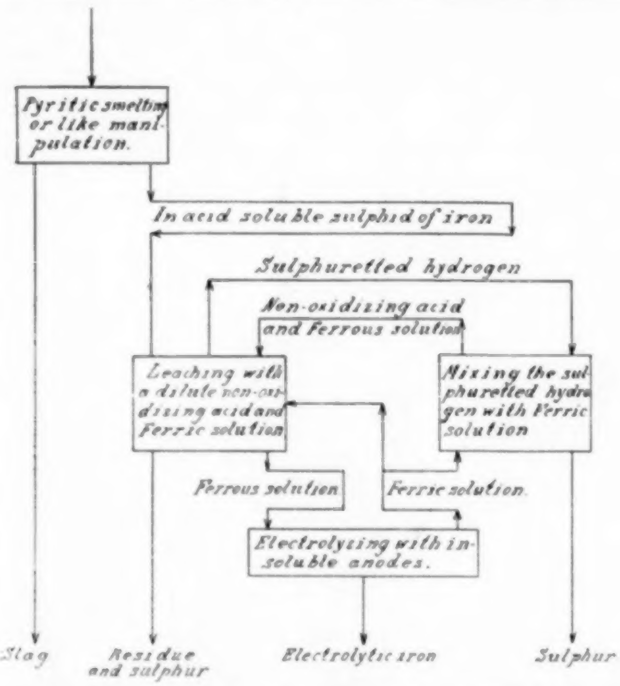


FIG. 1—ELECTROLYTIC IRON FROM PYRITIC ORE

the ore. The iron product is then treated with hydrochloric acid, yielding ferrous chloride and hydrogen sulphide. In the subsequent electrolysis a part of the iron is deposited while twice the amount is converted into ferric chloride. The latter is then passed, together with an equivalent quantity of hydrogen sulphide, into an absorption tower where the reaction yields ferrous chloride, hydrochloric acid and sulphur. The solvent thus regenerated is used again on fresh ore. (1,162,150, Nov. 30, 1915.)

Gold and Silver

Improved Process of Cyaniding.—With a view to increasing the efficiency and reducing the expense of cyaniding gold and silver ores, HARAI R. LAYNG of San Francisco, Cal., has patented a process of treatment. The principal object of the procedure is to minimize losses of cyanogen by conducting the treatment wholly or in part in closed vessels, and to provide means for recovering cyanogen now lost through volatilization or undesirable combinations with metals other than those sought, as well as from discarded residues and waste solutions. The patent specifications are lengthy and in considerable detail, and should be consulted by those interested in the subject. (1,178,081, April 4, 1916.)

Agitating and Settling Tank.—An agitator suitable for the treatment of slime pulp in the cyanidation of ores is patented by JOHN E. ROTHWELL of Butte, Mont., and assigned to the Colorado Iron Works Company, Denver. Combined with the agitator is means for simultaneously withdrawing clear liquid while agitation is in progress, and for withdrawing from the tank at a point above the pulp level a portion of the pulp under treatment. The apparatus is shown in Fig. 2. It consists of a cylindrical tank with conical bottom, with a central air-lift for circulating pulp. Within the cylindrical portion is an annular partition or skirt 3, which provides a quiet settling zone from which clear solution can be withdrawn while agitation of the balance of the pulp is in progress within the partition. The air-lift elevates the mixture that settles at the bottom of the cone, as well as that part of the pulp which settles between the outer and inner pipes of the central column. The discharge is made over a flanged plate above the surface of the pulp, falling into the zone within the partition 3. A portion of the elevated mixture is cut out by the sampling vane 11 for transfer to another agitator or vessel. (1,179,658, April 18, 1916.)

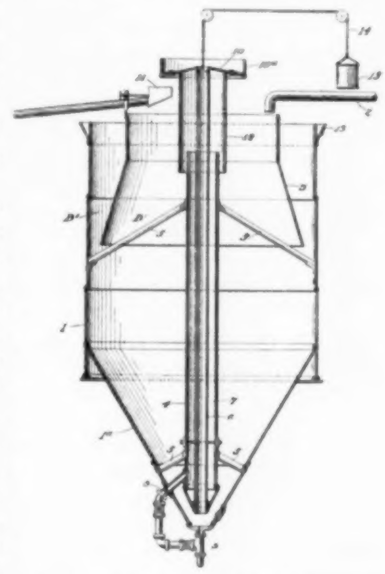


FIG. 2—AGITATING AND SETTLING TANK

Method and Apparatus for Desulphurizing Refractory Ores.—A wet process of desulphurizing gold and silver ores to make them more amenable to cyanidation is the basis of patents granted to EDWARD H. DICKIE of Goldroad, Ariz. The apparatus consists of a filter-bottom tank in which are suspended air-lifts that can be moved in circular paths through the pulp. The air-lift pipes have linings and coverings of aluminium, which react with the ore and the caustic soda solution in which it is ground. When the tank is used as a filter, the air-lifts serve to keep the solids in suspension and prevent their accumulation on the tile bottom. (1,177,394-6, March 28, 1916.)

Copper, Lead, etc.

Electrolysis of Copper Leaching Solutions.—According to methods disclosed in a patent granted to WILLIAM E. GREENAWALT of Denver Col., the usual difficulties attending the electrolysis of sulphate solutions from copper leaching can be overcome. The difficulties have been due to (1) the insoluble anode, (2) electrode inefficiency due to useless oxidation and reduction, and (3) fouling of the electrolyte. Oxidation and disintegration of the lead anode has been an obstacle to successful electrolysis, the presence of ferric sulphate has caused redissolution of deposited metal, and the accumulation of impurities in the electrolyte has resulted in deposition of impure metal and in poor leaching. The inventor claims to have overcome these troubles in a large degree. He uses a diaphragm cell, with the copper solution as catholyte, and either depleted cathode solution or acid wash water from the treated ore as anolyte. Both solutions are preferably saturated with sulphur dioxide. In operation, while copper is deposited at the cathode, acid solution is regenerated at the anode, so that the catholyte can be wasted without perceptible loss. The diaphragm and a continually changing anolyte prevents the ferric sulphate from coming in contact with deposited copper, while in the presence of sulphur

dioxide an excess of acid is regenerated. Only a minimum amount of lead is peroxidized—about 1 ounce of lead per pound of copper deposited—and this is automatically removed. Impurities in solution can be kept down to limits that do no harm, as determined by experiment, by regulating the quantity wasted. (1,179,-522, April 18, 1916.)

Hydrometallurgy of Copper.—A process of leaching copper ores with an acid chloride solution, precipitating the copper with hydrogen sulphide and subsequently electrolyzing the copper sulphide, is patented by WILLIAM E. GREENAWALT of Denver, Col. The metal is leached from the ore principally as cupric chloride and the solution is treated with sulphur dioxide, resulting in acid regeneration as follows:

$$2CuCl_2 + SO_2 + 2H_2O = 2CuCl + H_2SO_4 + 2HCl$$

The copper is then precipitated by hydrogen sulphide, with the further regeneration of acid, as follows:

$$2CuCl + H_2S = Cu_2S + 2HCl$$

Three molecules of acid are regenerated by sulphur dioxide and two by hydrogen sulphide, which is two and one-half times as much as would result if the original solution were precipitated directly with H_2S.

The precipitated copper is now in the form of pure sulphide without contamination with iron, and may be electrolyzed as anode without danger of fouling solutions. The power required is materially less than when copper is deposited from its solutions with insoluble anodes. (1,180,844, April 25, 1916.)

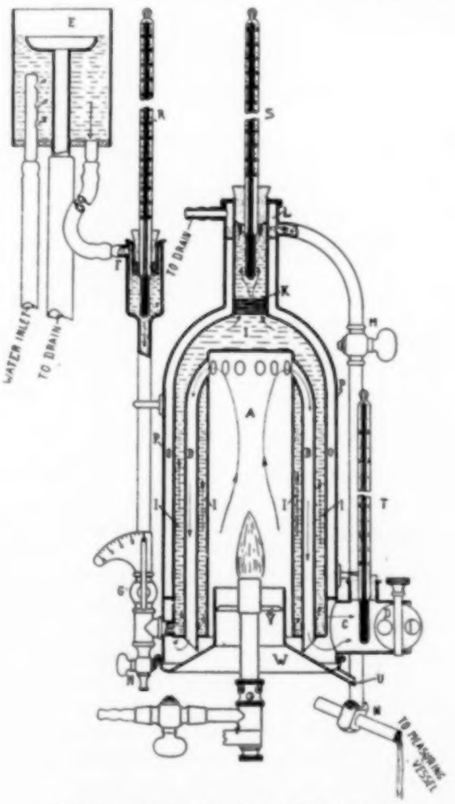
Leaching Copper Ores with Aluminum Sulphate Solution.—A proposed method for extracting copper from its ores is patented by EUGENE ERDÖS of Kolozsvar, Austria-Hungary, based on the use of solutions of aluminium sulphate, with a method for regenerating the solvent. Sulphide combinations of copper must be first roasted to oxide, but oxidized and carbonate forms are directly amenable. In the course of the treatment, basic salts of copper and aluminium are formed which are subsequently broken up by sulphuric acid, with the regeneration of aluminium sulphate. The separation of copper from the solution can be accomplished by evaporation and fractional crystallization. Copper sulphate is soluble at 70 deg. C. in a quantity of water equal to its own weight, while aluminium sulphate remains in solution in its own water of crystallization. (1,162,044, Nov. 30, 1916.)

Precipitating Apparatus for Copper Solutions.—As a compact form of precipitating apparatus, in which copper sulphate solutions can be treated with scrap iron, JOSEPH IRVING, JR., of Douglas, Ariz., patents the use of a Dorr thickener of special construction. The patent is assigned to the Dorr Cyanide Machinery Company. The apparatus consists of a circular tank in which is a support for the iron precipitant. The pregnant solution enters the tank through a central well that extends below the support, and flows upward through the pieces of iron. The copper precipitate scales off from the iron and falls to the bottom of the tank, where it is removed to a central point by the rakes and discharged. The spent solution overflows at the periphery of the tank. (1,177,109, March 28, 1916.)

Construction for Electrolytic Vat.—A type of vat suitable for leaching copper ores or electrolyzing copper sulphate solutions is patented by HARRY H. STOUT of New York City, the patent being assigned to the Nichols Copper Company of New York City. The vat is rectangular and built of brick laid in cement mortar and reinforced with iron plates and rods. On the interior surface the mortar is recessed and the space filled with a priming coat of an organic substance dissolved in a volatile medium, such as asphalt and gasoline. A second coating is applied over the entire interior surface, consisting of commercial asphaltum. This coating should be composed of material having a melting point below 300 deg. Fahr., and should not flow from position at or below 135 deg. Fahr. A vat thus constructed is resistant to the attack of acids or accidental blows. (1,169,205, Jan. 25, 1916.)

An Industrial and Laboratory Gas Calorimeter

A gas calorimeter apparatus for determining exactly and quickly the heating value of gases and liquid fuels, which is smaller than the standard form of gas calorimeters, is made by Wm. Gaertner & Co., 5345 Lake Park Avenue, Chicago, Ill., under the name of the Scientia calorimeter. The calorimeter is of the Junker type and its present form has been developed after considerable research work and experimenting. The complete outfit consists of the Junker calorimeter body, constant level water tank, thermometers, burner, two nickeled weighing pails, gas meter, gas pressure regulator, platform balance, and set of weights.



CROSS SECTION OF CALORIMETER

The calorimeter is shown in cross-section in the accompanying illustration. The following letters explain the diagram: *A* combustion chamber, *B* condenser tubes, *C* outlet for exhaust, *D* damper for exhaust, *E* inlet overflow weir, *F* water inlet, *G* inlet water valve, *H* drain cock, *I* water space, *K* mixing device, *L* outlet overflow weir, *M* shut-off cock, *N* change over device, *O* air space, *P* outer casing, *R* inlet water thermometer, *S* outlet water thermometer, *T* exhaust thermometer, *U* condensate drain, *V* centering device for burner, *W* detachable exhaust chamber. The heat of the gas to be measured is imparted to a stream of water, and the amount of water flowing through the calorimeter in the time that a known volume of gas is burned in the calorimeter and the resulting change in temperature of the water, furnish the necessary data for calculating the calorific value of the gas. The calorimeter vessel and inlet water tank are supported on a rod and tripod.

Quartz Resistance Thermometers

The increasing tendency toward the use of multiple recording thermometers and pyrometers for many industrial purposes has created a demand for measuring instruments for long-distance work. Thermometers of this class working on the electric resistance system are made by the Hanovia Chemical & Manufacturing Co., Newark, N. J. These are known as Heraëus quartz resistance thermometers.

The complete apparatus consists of the thermometers, connecting leads, battery, and an indicator mounted on a switchboard panel on which is also a series of buttons, which when pressed one at a time record the temperature at the different points where the thermometers are placed. A sliding rheostat for adjustment of the battery voltage is also placed on the switchboard, for correcting the zero point of the indicator dial.

The thermometers are made on the Wheatstone-bridge principle, having three known resistances whose values do not change with the temperature, and a fourth resistance of chemically pure platinum wire which forms the actual measuring element. The spirals are wound on fused quartz tubes 3 mm. and 6 mm. long. These are again enclosed in outer quartz tubes, hermetically sealed by fusion. The fused quartz remains unaffected by violent temperature fluctuations, and protects the platinum spool against deterioration.

For scientific work a transparent quartz tube is joined to the resistance unit and no protection tube is necessary, but for industrial purposes a more rugged mounting of double steel rods is used. Protection tubes may be of iron, steel, copper, nickel, lead or silica, depending on conditions under which the thermometer is to be used.

The indicators are highly sensitive galvanometers moving on a graduated scale. The scale limits may be — 200 deg. C. to + 700 deg. C., or may have a smaller range. By combining thermo-electric pyrometers on the same switchboard and equipping the indicator with an additional scale, the upper limit may be extended to + 1600 deg. C.

Instead of the indicating instruments described, continuous recorders are also furnished.

Improvements in the Technique of Brinell Hardness Determinations

The application of the Brinell method of determining the hardness of metals—adopted as "standard" by the American Society for Testing Materials and the Society of Automobile Engineers—has so far been limited by three causes:

First, no device was formerly available for application of the Brinell principle which could be used for tests at any chosen spot of a large mass of metal (such as large castings, etc.), for tests on metal products of irregular shape, and on hollow metal bodies.

Second, thin metal sheets (of iron, copper, brass, aluminium, etc.) could not be tested heretofore by the Brinell method, because the 10-mm ball would quickly penetrate the thin metal section on account of the high pressure applied.

Third, no apparatus working on the Brinell principle had formerly been designed which could be carried around (by metallurgists, testing engineers, steel inspectors, steel salesmen, etc.), weighing not more than, say, 7 lbs.

Another important point often overlooked is that a "specimen" cut from the metal to be tested does not always represent the true average hardness of the entire mass under investigation. In metal products like car wheels, rails, etc., considerable differences often appear in the hardness of the various sections.

All these difficulties have been overcome by the development of the "Brinell Meter," designed and patented by the Metallurgical Department of the Standard Roller Bearing Company. In this portable apparatus a 10-mm nickel steel ball is simultaneously brought into contact on one side with the metal under investigation, and on the other side with a bar of known Brinell hardness. It will be readily understood that any pressure applied to the assemblage presses the ball with exactly the same force into the metal of unknown hardness as into the metal of known Brinell hardness. The Brinell hardness of the two metals is in direct relation to the proportion of the two indentations, varying directly as the spherical areas of the two impressions, consequently varying directly as the squares of the diameters of the two indentations. On this basis, direct-reading Brinell hardness tables have been worked out which are furnished with each instrument.

Since the "standard bars" furnished have four machined surfaces 6 x ½ in., which can be ground off and can be used several times over, each bar can be utilized for several hundred tests. In this way, the cost of each Brinell test is much smaller than with the Brinell machine, eliminating the time and work of "cutting the specimen." The measuring range of each standard bar is quite large, as the determination depends on the proportion of the two indentations; a standard bar of No. 250 Brinell hardness, for instance, serves conveniently for Brinell tests from No. 180 to No. 330 Brinell units. Brass bars of known Brinell hardness can be supplied for Brinell tests on brass, copper, aluminium, etc.

The more important advantages of the new "Brinell meter" may be summarized as follows:

The Brinell method is made independent of the dimensions, shape, and location of the metal mass under investigation.

The "sampling error" in cutting specimens for tests in the Brinell machine is eliminated, as the instrument can be applied to any chosen spot of a large mass of metal, horizontally as well as vertically.

Metals of great softness can be tested just as ac-

THE BRINELL METER

curately as metals of usual hardness; thin sheets can be tested just as well as thick sections.

The complete Brinell meter outfit, in carrying case, only weighs 6½ lb., so that it can be conveniently carried around the plant by the metallurgist or engineer of tests; it can be taken on trips by salesmen and trouble investigators employed by the steel companies, etc.

The apparatus is simple in construction and is easily applied; any workingman of average intelligence can now make accurate Brinell tests. No part of the instrument can get out of order.

The complete outfit is low in price, so that metallurgical plants can easily afford to have a number of them around the shops, the foundry, the forging plant, the rolling mill, the laboratory, etc.

The Brinell meter, protected by patents on the method of determination and on the construction of apparatus, is manufactured, under sole license agreement, by Mr. Herman A. Holz, 50 Church Street, New York.

A Portable Hydraulic Hardness Testing Machine

For a number of years the metal industries of the United States and other countries have been seeking a method of securing definite and accurate determinations for hardness of metals to take the place of the so-called comparative tests made with a number of instruments.

Practically all testing engineers and metal workers have been making investigations relative to hardness measurements with little definite success, until the introduction of the Brinell method, which has been used in various ways with such success that it is now recognized universally as the standard, because the results obtained by its use can absolutely be depended on. For this reason the application of this method is especially valuable for structural material, rails, automobile parts, etc., and for ascertaining the effects of annealing and hardening of steel.

A hydraulic hardness testing machine of the Brinell principle has been manufactured by the Pittsburgh Instrument & Machine Co., Pittsburgh, Pa., for several years; it is a compact apparatus and its construction such that it brings results. These machines are of heavy construction, which makes it necessary to place them permanently and carry all test pieces to the location of the machine.

Numerous firms have made inquiries for a portable instrument, one that can be carried to the point where the materials collect. In order to meet the demand for such an instrument the Pittsburgh Instrument & Machine Co. has designed a hydraulic hardness testing machine of the Brinell principle which can be carried from one location to another by one man.

The working mechanism of this new apparatus has been somewhat reduced, but the change has been accomplished without reducing the general efficiency shown by the larger type machine.

The accompanying illustration shows the smaller apparatus.

HARDNESS TESTING MACHINE

Industrial Notes

Metric System in Denmark.—According to Commerce Reports the American Consul at Copenhagen, Denmark, reports that beginning with April 1, 1916, the old system of the pound in weights and the alen in measurement was discontinued and the metric system adopted. All dealers in goods sold by weight are now required to sell them by the kilogram or meter.

Chemicals from Great Salt Lake.—The Salt Lake Chemical Company has been incorporated to extract chemicals from the waters of the Great Salt Lake at Grants, Utah. The chief constituent is common salt.

Electrolytic Bleaching Plant.—A plant for the electrolytic bleaching of sulphur pulp will be erected by the Eastern Chemical Company, South Brewer, Me.

The Laboratory Supply Co., Columbus, Ohio, has issued a catalog of its special "made in America" laboratory supplies, including porcelain, glassware, rubber goods, and other materials.

Production of Coal-Tar Products.—According to Commerce Reports the estimated production of coal-tar crudes in the United States is at present at the following annual rates: Benzol, 90,000 tons; toluol, 22,440 tons; naphthaline, 12,500 tons; phenol (chiefly synthetic), 10,000 tons.

The Seaboard By-Product Coke Company is erecting a 110-oven by-product coke plant at Jersey City, N. J. The plant is being built by the H. Koppers Company, Pittsburgh, Pa.

The Combustion Engineering Corporation, 11 Broadway, New York, has moved its offices from the thirteenth floor to larger offices on the eighth floor in the same building. The increase in business in the last four years has made necessary an increase in office space of five times the amount occupied in 1912.

The Union By-Product Coke Company, Buffalo, has begun the erection of a by-product coke plant to cost, with the land, $1,800,000. Westinghouse, Church, Kerr & Co., are supervising the construction while the actual work is in the hands of the American Coal & By-Products Coke Company.

The second annual edition of the **Zinc and Lead Handbook,** published by the Joplin News-Herald, has

been issued recently. This useful little book, edited by L. L. Wittich, contains much information compiled from various sources on zinc and lead in the Joplin district, together with a map of this district, and other general information on these two metals.

The Schutte and Koerting Company, Philadelphia, Pa., has issued additions to its catalog as follows: Catalog 8, Section L, describing lead lined valves and Catalog 7, Section L, describing hard lead and rubber fittings.

The Goldschmidt Thermit Co., New York City, announces the removal of its main office to the Equitable Building, 120 Broadway.

The Sarco Company, Inc., Woolworth Building, New York City, has issued a little booklet on Sarco temperature control, which explains the operation of its temperature regulators, for tanks, containers, rooms, etc. The regulators control automatically the temperature of air, or any gas or liquid.

University of California Establishes Course in Chemical Engineering.—Chemical engineering is to be established as a separate new course in the University of California. In the junior year the course will include studies in organic and physical chemistry, steam engineering, hydraulics, advanced physics and economics. The senior year will be devoted to the study of organic and technical chemistry, thermo-dynamics, applied electro-chemistry, laboratory training in experimental engineering in water, steam and gas engines, and work in the field of electrical machinery.

The Electric Smelting & Reduction Co., Portland, Me., has been incorporated to conduct a general mining, smelting and refining business. The capital stock is $150,000.

Lead as Substitute for Galvanizing.—The Ledcote Company of Canada, Ltd., Amherst, N. S., contemplates the erection of a plant for covering sheets with lead as a substitute for galvanizing.

The Sweetland Filter Press Co., Inc., announces that owing to increasing business it has leased the entire floor of the new Sperry building, 36 Flatbush Avenue Extension, Brooklyn, and that its offices, laboratory and test plant were removed to that address on May 1.

The Doehler Die-Casting Co., Brooklyn, N. Y., announces that it has acquired a controlling interest in the American Die Casting Co., of Newark, N. J., which will hereafter be known as the Doehler Die-Casting Co. of New Jersey.

Industrial Exhibition in Jersey City.—The manufacturers and retail merchants of Jersey City are cooperating in an industrial exhibition of Jersey City made goods, to be held June 5-10. This exhibition will differ from the general run of industrial displays in the fact that instead of grouping the exhibits in any one hall or building, each retail merchant will turn his store into a show room for some particular manufactured article, which is made in this city and which he can commercially handle.

New Molybdenum Smelting Plant.—The International Molybdenum Co. has been incorporated in Canada and contemplates the erection of a smelting plant at Renfrew, Ontario.

The Aetna Chemical Company of Canada, Ltd., will erect a $300,000 sulphuric acid plant at Drummondville, Quebec. The construction work is in charge of Westinghouse, Church, Kerr & Co., New York City.

The Consolidated Mining & Smelting Company is erecting a sulphuric acid and hydrofluoric acid plant at its smelter at Trail, B. C.

The Chicago Pneumatic Tool Co., has issued bulletin No. 34-Q, describing applications of Giant gas and fuel oil engines.

Chromic Iron Ore.—The production of chromic iron ore or chromite in the United States in 1915 was 3281 tons, valued at $36,744, according to the Geological Survey report of J. S. Diller. This was a gain of 2690 tons over the 1914 production. The output came entirely from California.

Antimony.—The Magnolia Metal Co., is producing a small quantity of antimony from its new smelting plant at Matawan, N. J. This is the only plant on the Atlantic Coast smelting antimony.

The Liberty Bell Mine Crew was given its second safety-first dinner on April 7, 1916, at Telluride, Col. This is the second year since the crew was formed without fatal accident and with few serious mishaps, and the dinner was given in recognition of this achievement.

The Quigley Furnace Specialties Company has been formed with offices at 26 Cortlandt Street, New York City, Mr. W. S. Quigley being the president. All the members of the organization have had years of experience in specializing in the fuel and furnace line. The "furnace specialties department" will manufacture and deal in a line of high-grade furnace materials, equipment and appliances for the improvement of furnace construction, operation and methods, such as high-temperature furnace cements, insulating brick, automatic fuel-oil valves, oil, gas and powdered-coal burners, temperature and draft-recording and controlling systems, gas-analyzing instruments, etc. The "engineering and contracting department" is prepared to analyze and compare the operating costs of powdered coal, hand or stoker-fired coal, gas and fuel oil, make recommendations as to the most economical fuel and its applications and furnish complete plans, specifications and supervision for the entire installation of any fuel.

Courses in Foreign Trade Announced

Dr. Edward E. Pratt, Chief of the Bureau of Foreign and Domestic Commerce of the United States Department of Commerce, is the director of an educational course in foreign trade which has just been announced. Associated with Dr. Pratt in the preparation of the course are men prominent in American export activities, including O. P. Austin, of the National City Bank of New York; E. N. Vose, editor of *Dun's International Review;* E. A. De Lima, president of the Battery Park National Bank of New York; Prof. Emory R. Johnson and Dr. G. G. Huebner, of the University of Pennsylvania, and several others. The course in foreign trade is designed to aid manufacturers, banks, export houses and other concerns in giving adequate training to the men in their organizations who are handling or may be developed to handle their foreign business. The course covers a treatment of the various factors entering into export marketing, such as world trade economics, export policies, export houses, direct exporting, the export salesman, shipping, financing, export technique, foreign and home law, and importing. The course is being issued through the Business Training Corporation, with offices at 185 Madison Avenue, New York.

Personal

Mr. Warren P. Blauvelt has been engaged by the Steere Engineering Company, Detroit, Mich., to devote his entire time to the company. He will give special attention to plant design and the solution of operating problems, and to the improvement of apparatus and methods in the gas industry.

Mr. Alexander C. Brown, formerly vice-president, has been appointed general manager of The Brown Hoisting Machinery Company, Cleveland, Ohio, succeeding Mr. Richard C. Sheridan, who has resigned to accept another position.

Mr. **A. E. Drucker** has completed his work at the Frontino-Bolivia mill in Columbia, and expected to sail from New York for London on the 11th inst.

Mr. **W. E. Gray, Jr.**, representing the Elyria Enameled Products Company in the Pittsburgh district, has opened an office for the company at 1237 Oliver Building, Pittsburgh.

Mr. **Geo. H. Higgins** has been appointed factory manager of the Burd High Compression Ring Company, Rockford, Ill. He was formerly associated with the Stone & Webster Corporation, the Westinghouse Electric & Manufacturing Company, and several motor car companies.

Mr. **Alonzo G. Kinyon**, superintendent of locomotive operation on the Seaboard Air Line Railway for a number of years, has resigned this position to become chief consultant of the board of engineering research power generation in steam locomotives for the Powdered Coal Engineering & Equipment Company, Chicago. Mr. Kinyon's knowledge of locomotive combustion, drafting and fuel economy tests began when a young man as locomotive fireman on the Chicago, Milwaukee & St. Paul Railway, and for the last twenty-eight years he has done nothing else but burn coal as a fuel. For a number of years he was advisory consultant of combustion for the International Correspondence School of Scranton. He is at present vice-president of the Traveling Engineers' Association and a member of the executive committee of the International Railway Fuel Association.

Dr. **Julius Koebig**, consulting chemical and mining engineer, announces the removal of his office to 329 Union Oil Building, Los Angeles, California.

Mr. **E. A. Mitchell**, president of The Wyckoff Pipe & Creosoting Company, Inc., New York City, has bought a large coal mine in Alabama on the Black Warrior River. This coal has been tested and found to be a much better coal than the Pocahontas. Mr. A. E. Mitchell, a well-known engineer, who is also an expert on coal values, states that this coal is one of the best for making coke. The company may also build coke ovens and chemical plant for making creosote oil and other byproducts.

Mr. **H. W. Seldon**, formerly assistant metallurgist of the Cambria Steel Company, is now in charge of the metallurgical department of the Scientific Materials Company, Pittsburgh, Pa.

Mr. **J. E. Simpson** will shortly open a Chicago office for the Elyria Enameled Products Company, and will have charge of the company's business in that district. He may be addressed temporarily in care of the Morrison Hotel, Chicago.

Mr. **James R. Stack**, formerly chemist at the Perth Amboy plant of the American Smelting & Refining Company, has been appointed chief chemist of the Baltimore Copper Smelting & Rolling Company, Baltimore, Md.

Mr. **F. R. Wadleigh**, consulting engineer in coal and coke, announces the removal of his office to 1418 Walnut Street, Bellevue Court Building, Philadelphia, Pa.

Obituary

Lucien I. Blake, well known for his work in the field of physics and electricity, and particularly electrostatic ore separation, and as inventor of the submarine signal, died in Boston early in May. He was born in Mansfield, Mass., on Sept. 12, 1854. He received the degree of A.B. from Amherst College in 1877, was Tyndall fellow at Harvard 1881-83, and then went to Berlin, where he received the degree of Ph.D. in 1884. In 1884-5 he was assistant professor of mathematics at Adelphi College, from 1885 to 1887 professor of physics and electrical engineering at Rose Polytechnic Institute, and held the same position at Kansas University from 1887 to 1905. He left Kansas to go to Colorado and develop his electrostatic ore separator, which was subsequently introduced on a commercial scale for the separation of complex sulphide ores. His greatest invention was probably the submarine signal. He was chief engineer of the Submarine Signal Co., and director and engineer of the Blake-Morscher Electrostatic Ore Separating Co. Dr. Blake was married in Denver in the spring of 1911, and immediately went to Europe for several years. He was an excellent lecturer, and gave a summer course at Berkeley in 1914 on cosmic physics. Later the same course was repeated in popular form in Denver in the spring of 1915. He recently completed a condensed course on the same subject at Union Theological Seminary, New York. He was a member of the American Physical Society, American Electrochemical Society and American Chemical Society.

Book Reviews

Coal: Its Economical and Smokeless Combustion. By **James F. Cosgrove.** Octavo (13 x 21 cm.), 281 pages, 33 illustrations. Price, $3.00. Philadelphia: Technical Book Publishing Company.

Intended to explain to the general public in clear, simple language the characteristics of various kinds of coal, so that they may be bought intelligently and burned economically and smokelessly. It contains much good practical horse-sense on the fuel question, and is well suited to its avowed purpose. The author slips up in some small details of the scientific aspects of the question, but the faults are minor ones.

Lehrbuch der Eisenhüttenkunde. Vol. I: Roheisenerzeugung. By **Bernhard Osann.** 15 by 23 cm. xiii + 668 pages, 17 tables, 407 illustrations; price 30.50 marks. Leipzig: Wilhelm Engelmann.

Professor Osann of the Mining Academy of Clausthal, well-known for his handbook on iron and steel castings, gives us here the first installment of a comprehensive work on iron and steel—The Production of Pig Iron. Volume II will treat of the manufacture of malleable iron and steel.

The work is painstakingly written, but somewhat labored. The author has the technique well mastered, but the general points of view from which the discussion proceeds are sometimes poorly chosen; for instance, the treatment of the efficiency of blast-furnace working from the standpoint of the "reduction figure"—a frequently faulty and altogether unsatisfactory criterion. In 1905 Professor Osann made a faulty criticism of the Gayley dried blast process, making erroneous calculations to substantiate his position, and although he has since been shown to be very far from right, yet the whole question of dry-blast is here discussed from the same erroneous standpoint, and not from the much better and more lucid reasoning from a critical smelting temperature, such as advanced by J. E. Johnson, Jr.

And so on, while leafing through the book, there are to be found reams of useful information, but also numerous points of theory or opinion which are doubtful or debatable, with the opposing views omitted.

If Ledebur's classic work is unfortunately becoming antiquated, then Professor Osann's work may have a *raison d'être*, but it is not yet its equal in judgment and breadth of view. Its principal value will be to inform readers on *the present facts* of the metallurgy of iron; but many of the author's theories and explanations need to be read critically.